PUBLIC LECTURE SERIES

Initial Exoplanet Discoveries from TESS

Featuring Guest Speaker:
Scott Fleming

1
00:00:05,030 --> 00:00:02,480
you've got one of these our lithographed

2
00:00:10,400 --> 00:00:05,040
we're doing tonight is the bubble nebula

3
00:00:13,039 --> 00:00:10,410
also know this NGC 76 35 and it's a

4
00:00:16,160 --> 00:00:13,049
beautiful beautiful blue bubble of a

5
00:00:18,560 --> 00:00:16,170
nebula blown by that star in the center

6
00:00:20,960 --> 00:00:18,570
there if you want to understand how this

7
00:00:23,689 --> 00:00:20,970
all happens you can turn over on the

8
00:00:26,839 --> 00:00:23,699
back and there are there are a few

9
00:00:30,439 --> 00:00:26,849
paragraphs explaining what's going on in

10
00:00:34,400 --> 00:00:30,449
this nebula tonight's talk will be

11
00:00:37,220 --> 00:00:34,410
initial exoplanet discoveries with Tess

12
00:00:39,110 --> 00:00:37,230
and I will say that I heard a whole

13
00:00:41,389 --> 00:00:39,120

bunch about the test discoveries last

14
00:00:43,280 --> 00:00:41,399
week I'm waiting for Scott here tonight

15
00:00:46,069 --> 00:00:43,290
to clarify them for me so I really

16
00:00:47,540 --> 00:00:46,079
really understand them because it was at

17
00:00:49,970 --> 00:00:47,550
the American Astronomical Society

18
00:00:52,150 --> 00:00:49,980
meeting last week and it's a whirlwind

19
00:00:54,200 --> 00:00:52,160
week you get presented so many results

20
00:00:57,170 --> 00:00:54,210
it'll be nice to be able to sit back and

21
00:00:58,060 --> 00:00:57,180
relax and really enjoy Scott's talk

22
00:01:01,069 --> 00:00:58,070
tonight

23
00:01:04,520 --> 00:01:01,079
next month February we have your place

24
00:01:07,969 --> 00:01:04,530
in the stars from mi Amoro Martin here

25
00:01:12,230 --> 00:01:07,979
at Space Telescope and in March and

26
00:01:14,420 --> 00:01:12,240
April we have the infamous TBA which

27
00:01:17,359 --> 00:01:14,430
means actually that is very hard to

28
00:01:19,850 --> 00:01:17,369
pigeonhole astronomers to commit before

29
00:01:21,770 --> 00:01:19,860
the holidays so now that it's past the

30
00:01:23,690 --> 00:01:21,780
holidays and past the double-a s meeting

31
00:01:25,550 --> 00:01:23,700
I could actually start getting them to

32
00:01:27,410 --> 00:01:25,560
commit and I will fill out the calendar

33
00:01:30,050 --> 00:01:27,420
for the rest of the year all right

34
00:01:33,649 --> 00:01:30,060
please check the website Oh what website

35
00:01:35,780 --> 00:01:33,659
you say well here this is our website

36
00:01:37,190 --> 00:01:35,790
for the public lecture series if you go

37
00:01:39,800 --> 00:01:37,200
to your favorite search engine and type

38
00:01:44,240 --> 00:01:39,810

in Space Telescope public lecture series

39
00:01:46,429 --> 00:01:44,250
you'll find this which has which has the

40
00:01:50,060 --> 00:01:46,439
link to the upcoming lectures over here

41
00:01:53,389 --> 00:01:50,070
it has our links to our live webcasting

42
00:01:56,450 --> 00:01:53,399
as well as our past lectures all the way

43
00:01:58,670 --> 00:01:56,460
back to 2005 for some of them although

44
00:02:02,209 --> 00:01:58,680
those are low resolution stuff the stuff

45
00:02:06,170 --> 00:02:02,219
since 2014 is all the high resolution HD

46
00:02:09,139 --> 00:02:06,180
stuff and you can also sign up for our

47
00:02:11,860 --> 00:02:09,149
email list speaking of our email list

48
00:02:13,960 --> 00:02:11,870
these are just announcements that we do

49
00:02:16,060 --> 00:02:13,970
once or twice a month to

50
00:02:17,320 --> 00:02:16,070
tell you of the next lecture and where

51
00:02:20,170 --> 00:02:17,330
the other liked lectures when the

52
00:02:22,660 --> 00:02:20,180
lectures are webcast and archive is

53
00:02:26,590 --> 00:02:22,670
posted etc and so far we haven't had any

54
00:02:29,200 --> 00:02:26,600
span if you have comments or questions

55
00:02:34,030 --> 00:02:29,210
and you can send them to us at public

56
00:02:37,180 --> 00:02:34,040
lecture at STScI dot edu ok ah social

57
00:02:38,350 --> 00:02:37,190
media Hubbell the James Webb Space

58
00:02:40,120 --> 00:02:38,360
Telescope and the Space Telescope

59
00:02:42,220 --> 00:02:40,130
Science Institute have the variety of

60
00:02:44,830 --> 00:02:42,230
Facebook and Twitter and YouTube and

61
00:02:47,830 --> 00:02:44,840
Instagram and myself I do a tiny bit on

62
00:02:50,710 --> 00:02:47,840
Facebook Google+ and Twitter if you are

63
00:02:52,270 --> 00:02:50,720

so interested now across the street we

64
00:02:56,199 --> 00:02:52,280
have the Maryland Space Grant

65
00:02:58,199 --> 00:02:56,209
Observatory and every month we ask them

66
00:03:01,180 --> 00:02:58,209
are you going to be open tonight

67
00:03:03,850 --> 00:03:01,190
unfortunately tonight there is ice on

68
00:03:06,520 --> 00:03:03,860
the roof that leads to the observatory

69
00:03:09,280 --> 00:03:06,530
and they were told they cannot have a

70
00:03:10,900 --> 00:03:09,290
public group like this come over when

71
00:03:13,960 --> 00:03:10,910
there's ice until they get that gets

72
00:03:16,540 --> 00:03:13,970
cleared off so they do have open houses

73
00:03:18,970 --> 00:03:16,550
on Friday evenings if you go to MD dot

74
00:03:20,830 --> 00:03:18,980
space grant RG

75
00:03:22,479 --> 00:03:20,840
you will find you can find this web page

76
00:03:25,630 --> 00:03:22,489
where they talk about the observatory

77
00:03:27,880 --> 00:03:25,640
status and by like 5:30 on Friday

78
00:03:30,190 --> 00:03:27,890
evenings they post whether or not though

79
00:03:32,259 --> 00:03:30,200
we doing observing there so sorry no

80
00:03:35,680 --> 00:03:32,269
observing tonight but please check the

81
00:03:40,150 --> 00:03:35,690
website for more and now our news from

82
00:03:43,930 --> 00:03:40,160
the universe for January 2019 get to say

83
00:03:47,130 --> 00:03:43,940
a new year 2019 all right our first

84
00:03:49,870 --> 00:03:47,140
story tonight star clusters within

85
00:03:51,640 --> 00:03:49,880
galaxy clusters I was actually just

86
00:03:53,710 --> 00:03:51,650
having a discussion with one of our

87
00:03:55,210 --> 00:03:53,720
writers today she was just getting

88
00:03:57,580 --> 00:03:55,220

annoyed with having to write the word

89
00:03:59,740 --> 00:03:57,590
cluster so many times and it can mean so

90
00:04:02,350 --> 00:03:59,750
many different things well let's start

91
00:04:05,590 --> 00:04:02,360
with these star clusters because this is

92
00:04:07,390 --> 00:04:05,600
the globular star cluster Messier 80 and

93
00:04:10,600 --> 00:04:07,400
these globular star clusters are the

94
00:04:12,460 --> 00:04:10,610
really rich big star clusters that you

95
00:04:14,710 --> 00:04:12,470
contain as few as like ten thousand

96
00:04:17,740 --> 00:04:14,720
stars as many as a hundred thousand

97
00:04:21,130 --> 00:04:17,750
stars or even a few million stars these

98
00:04:24,310 --> 00:04:21,140
are giant giant star clusters and there

99
00:04:26,320 --> 00:04:24,320
are these are really good tracers of

100
00:04:28,059 --> 00:04:26,330
star clusters because there's there's

101
00:04:31,450 --> 00:04:28,069
because they can be so mass

102
00:04:34,420 --> 00:04:31,460
they can be seen very bright okay now

103
00:04:36,279 --> 00:04:34,430
when we're talking galaxy clusters one

104
00:04:40,390 --> 00:04:36,289
of the most famous is the Coma Cluster

105
00:04:42,939 --> 00:04:40,400
of galaxies kkoma is one of the biggest

106
00:04:45,249 --> 00:04:42,949
galaxy clusters out there it can galaxy

107
00:04:48,489 --> 00:04:45,259
clusters contain hundreds to thousands

108
00:04:50,800 --> 00:04:48,499
to even 10,000 galaxies kkoma contains

109
00:04:53,649 --> 00:04:50,810
several thousand galaxies and it's

110
00:04:57,040 --> 00:04:53,659
located about 300 million light-years

111
00:04:59,379 --> 00:04:57,050
away so what's the connection between

112
00:05:04,179 --> 00:04:59,389
these star clusters and these galaxy

113
00:05:07,240 --> 00:05:04,189

clusters well inside galaxy clusters we

114
00:05:11,469 --> 00:05:07,250
get a lot of this galaxy collisions

115
00:05:13,869 --> 00:05:11,479
because you have a dense environment for

116
00:05:17,950 --> 00:05:13,879
galaxies the galaxies can interact they

117
00:05:20,920 --> 00:05:17,960
can collide okay and two things happen

118
00:05:23,290 --> 00:05:20,930
one we have evidence from computer

119
00:05:25,300 --> 00:05:23,300
simulations this is a visualization of a

120
00:05:28,719 --> 00:05:25,310
computer simulation that during these

121
00:05:31,570 --> 00:05:28,729
galaxy collisions globular star cluster

122
00:05:34,240 --> 00:05:31,580
like things can be created so in the

123
00:05:36,610 --> 00:05:34,250
title tail of this galaxy here you can

124
00:05:38,469 --> 00:05:36,620
see these white dots okay and in this

125
00:05:41,140 --> 00:05:38,479
title tail you can see these white dots

126
00:05:44,920 --> 00:05:41,150
and the computer simulations show that

127
00:05:46,689 --> 00:05:44,930
these look like globular clusters so

128
00:05:49,179 --> 00:05:46,699
that you can create clobber your

129
00:05:50,950 --> 00:05:49,189
clusters during galaxy collisions the

130
00:05:52,990 --> 00:05:50,960
other thing that happens in galaxy

131
00:05:56,230 --> 00:05:53,000
collisions is that these star clusters

132
00:05:59,019 --> 00:05:56,240
actually become disassociated with the

133
00:06:01,450 --> 00:05:59,029
galaxies because they can actually get

134
00:06:03,760 --> 00:06:01,460
flung out to large distances and they

135
00:06:06,159 --> 00:06:03,770
are no longer bound to an individual

136
00:06:10,119 --> 00:06:06,169
galaxy but instead they're spread

137
00:06:14,860 --> 00:06:10,129
throughout the galaxy cluster so could

138
00:06:18,760 --> 00:06:14,870

we look for four star clusters within

139
00:06:20,459 --> 00:06:18,770
galaxy clusters and remember coma is 300

140
00:06:24,429 --> 00:06:20,469
million light years away

141
00:06:27,820 --> 00:06:24,439
what telescope could possibly have the

142
00:06:31,029 --> 00:06:27,830
incredibly exquisite resolution to be

143
00:06:32,860 --> 00:06:31,039
able to see globular clusters in a

144
00:06:34,079 --> 00:06:32,870
galaxy cluster 300 million light-years

145
00:06:37,860 --> 00:06:34,089
away

146
00:06:42,390 --> 00:06:37,870
of course it's everyone's favorite Oh

147
00:06:44,460 --> 00:06:42,400
this image is what is it this image is

148
00:06:47,520 --> 00:06:44,470
like twenty five thousand by sixteen

149
00:06:50,580 --> 00:06:47,530
thousand pixels so that orange rectangle

150
00:06:53,969 --> 00:06:50,590
I put there that is a full HD two

151
00:06:55,740 --> 00:06:53,979
million school pixel 1920 by 1080

152
00:06:57,719 --> 00:06:55,750
resolution let me blow that out for you

153
00:07:00,360 --> 00:06:57,729
so I blow up that orange rectangle there

154
00:07:03,150 --> 00:07:00,370
this is what Hubble actually sees at

155
00:07:05,030 --> 00:07:03,160
full resolution that's kind of cool for

156
00:07:07,830 --> 00:07:05,040
something 300 million light years away

157
00:07:10,230 --> 00:07:07,840
now can you see anything that might be a

158
00:07:13,110 --> 00:07:10,240
globular star cluster there are all

159
00:07:14,879 --> 00:07:13,120
these little dots there and and they

160
00:07:16,320 --> 00:07:14,889
could be stars in our own Milky Way

161
00:07:18,900 --> 00:07:16,330
galaxy that just happened to be in the

162
00:07:21,960 --> 00:07:18,910
foreground they could be star clusters

163
00:07:25,920 --> 00:07:21,970

in coma or they could be galaxies way in

164
00:07:28,950 --> 00:07:25,930
the background who knows well a research

165
00:07:31,710 --> 00:07:28,960
group went in and they did a cluster

166
00:07:34,760 --> 00:07:31,720
finding algorithm to determine what all

167
00:07:39,230 --> 00:07:34,770
these little dots are and the answer is

168
00:07:43,020 --> 00:07:39,240
most of them are globular star clusters

169
00:07:45,870 --> 00:07:43,030
yes every green circle identifies one

170
00:07:49,170 --> 00:07:45,880
globular star cluster in the Coma

171
00:07:51,629 --> 00:07:49,180
Cluster of galaxies so that's just one

172
00:07:55,050 --> 00:07:51,639
small portion of that image here we go

173
00:07:59,629 --> 00:07:55,060
out to the entire image there are 22

174
00:08:03,150 --> 00:07:59,639
thousand 429 globular star clusters

175
00:08:06,810 --> 00:08:03,160
found in the coma cluster with this new

176
00:08:09,089 --> 00:08:06,820
survey that's kind of cool we're looking

177
00:08:12,180 --> 00:08:09,099
300 million light years away and we're

178
00:08:15,210 --> 00:08:12,190
finding over 22,000 globular star

179
00:08:17,159 --> 00:08:15,220
clusters that's a huge population to

180
00:08:20,610 --> 00:08:17,169
study you can do all sorts of cool

181
00:08:24,300 --> 00:08:20,620
things with that kind of population but

182
00:08:26,460 --> 00:08:24,310
as I said before these star clusters

183
00:08:29,100 --> 00:08:26,470
have disassociated from their individual

184
00:08:31,440 --> 00:08:29,110
galaxies and they're now associated with

185
00:08:34,529 --> 00:08:31,450
the whole cluster and that gives you

186
00:08:37,940 --> 00:08:34,539
something else you can do which is our

187
00:08:43,260 --> 00:08:37,950
second story so the second story is

188
00:08:44,760 --> 00:08:43,270

visible tracers of dark matter so we're

189
00:08:46,949 --> 00:08:44,770
not going to talk about the Coma Cluster

190
00:08:49,110 --> 00:08:46,959
although this can be done for the Coma

191
00:08:51,370 --> 00:08:49,120
Cluster - we're going to talk about the

192
00:08:54,260 --> 00:08:51,380
galaxy cluster Abell

193
00:08:59,120 --> 00:08:54,270
s106 three it's part of the frontier

194
00:09:01,160 --> 00:08:59,130
fields program okay and this is a galaxy

195
00:09:04,070 --> 00:09:01,170
cluster that's so massive it has

196
00:09:07,160 --> 00:09:04,080
gravitational lensing there's so much

197
00:09:09,290 --> 00:09:07,170
mass mass warps the space and you can

198
00:09:12,110 --> 00:09:09,300
see these streaky are key things here

199
00:09:14,420 --> 00:09:12,120
those are gravitational lenses now

200
00:09:16,460 --> 00:09:14,430
gravitational lenses are due to the mass

201
00:09:18,980 --> 00:09:16,470
and if you measure the amount of

202
00:09:21,860 --> 00:09:18,990
gravitational lensing you can understand

203
00:09:25,130 --> 00:09:21,870
the mass so here is the cluster as seen

204
00:09:27,260 --> 00:09:25,140
from the Hubble image here is a map

205
00:09:29,780 --> 00:09:27,270
showing you a lot of the gravitational

206
00:09:32,720 --> 00:09:29,790
lensing effects that they've uncovered

207
00:09:34,580 --> 00:09:32,730
here and from those measurements of

208
00:09:37,970 --> 00:09:34,590
gravitational lensing they can then

209
00:09:40,490 --> 00:09:37,980
create a mass map of the cluster and

210
00:09:43,850 --> 00:09:40,500
this is the mass map of the cluster

211
00:09:47,690 --> 00:09:43,860
showing you the the contour lines of the

212
00:09:52,640 --> 00:09:47,700
mass inside the cluster now the cluster

213
00:09:56,180 --> 00:09:52,650

mass is dominated 80% by dark matter

214
00:09:58,910 --> 00:09:56,190
right the galaxies are tracers of it in

215
00:10:02,150 --> 00:09:58,920
some way but they're only 20% of their

216
00:10:04,070 --> 00:10:02,160
normal matter is at most 20% of the

217
00:10:06,020 --> 00:10:04,080
material in this cluster so we're trying

218
00:10:08,360 --> 00:10:06,030
to figure out where this dark matter is

219
00:10:11,480 --> 00:10:08,370
so by using gravitational lensing we can

220
00:10:13,190 --> 00:10:11,490
get an idea of where it is but that's

221
00:10:14,720 --> 00:10:13,200
sort of an indirect method because we're

222
00:10:17,480 --> 00:10:14,730
measuring the gravitational lensing to

223
00:10:21,110 --> 00:10:17,490
infer the mass distribution wouldn't it

224
00:10:23,030 --> 00:10:21,120
be cool if we had some some light

225
00:10:25,040 --> 00:10:23,040
luminous stuff that sort of spread

226
00:10:27,560 --> 00:10:25,050
across the entire and galaxy cluster

227
00:10:30,860 --> 00:10:27,570
that could tell us what the potential of

228
00:10:33,829 --> 00:10:30,870
the cluster is like those star clusters

229
00:10:37,010 --> 00:10:33,839
we just discussed so what the team did

230
00:10:39,680 --> 00:10:37,020
is they went into that Hubble image and

231
00:10:41,720 --> 00:10:39,690
they went very carefully into it to try

232
00:10:44,690 --> 00:10:41,730
and get rid of all the under normal

233
00:10:47,030 --> 00:10:44,700
light and pull out that very faint

234
00:10:48,440 --> 00:10:47,040
background light a very faint in truck

235
00:10:50,810 --> 00:10:48,450
cluster like the light between the

236
00:10:54,770 --> 00:10:50,820
galaxies okay and when they did that

237
00:10:57,770 --> 00:10:54,780
they're able to pull out that blue map

238
00:11:00,140 --> 00:10:57,780

there so this is the the galaxy cluster

239
00:11:03,410 --> 00:11:00,150
image with that blue map being that

240
00:11:04,700 --> 00:11:03,420
intra cluster light inferred from things

241
00:11:06,560 --> 00:11:04,710
like the star

242
00:11:10,940 --> 00:11:06,570
clusters that are orbiting within the

243
00:11:14,570 --> 00:11:10,950
galaxy cluster and using this they could

244
00:11:17,330 --> 00:11:14,580
use this as a tracer of the mass because

245
00:11:20,090 --> 00:11:17,340
they also have a gravitational lensing

246
00:11:22,370 --> 00:11:20,100
mass map they can correlate the two and

247
00:11:25,850 --> 00:11:22,380
they find that it correlates extremely

248
00:11:29,210 --> 00:11:25,860
well so this very fate intra luster

249
00:11:31,460 --> 00:11:29,220
light that they can in certain clusters

250
00:11:34,250 --> 00:11:31,470
of galaxies relate to the mass map by a

251
00:11:36,440 --> 00:11:34,260
gravitational lensing shoes uses that as

252
00:11:38,210 --> 00:11:36,450
a calibration to show that for other

253
00:11:40,460 --> 00:11:38,220
clusters they can take that inter

254
00:11:43,220 --> 00:11:40,470
cluster light and then use that as a

255
00:11:48,380 --> 00:11:43,230
visible tracer of the dark matter in

256
00:11:51,370 --> 00:11:48,390
galaxy clusters cool all right finally

257
00:11:54,140 --> 00:11:51,380
our third story which I could not ignore

258
00:11:58,370 --> 00:11:54,150
contact in the Kuiper belt

259
00:12:02,690 --> 00:11:58,380
so yeah the New Horizons mission was

260
00:12:04,910 --> 00:12:02,700
launched in 2006 and it went past

261
00:12:07,670 --> 00:12:04,920
Jupiter and it spent basically almost

262
00:12:11,810 --> 00:12:07,680
ten years nine years getting out to the

263
00:12:15,920 --> 00:12:11,820

Pluto Charon system and in July of 2015

264
00:12:19,070 --> 00:12:15,930
they flyby of Pluto and Charon and Nix

265
00:12:23,750 --> 00:12:19,080
and Hydra and I figure what the other

266
00:12:26,540 --> 00:12:23,760
ones are called fix and Kerberos yes all

267
00:12:28,820 --> 00:12:26,550
six objects in the Pluto Charon system

268
00:12:30,680 --> 00:12:28,830
and they're able to get amazing things

269
00:12:31,940 --> 00:12:30,690
and they've had a great success and

270
00:12:34,010 --> 00:12:31,950
they're out there and they're out

271
00:12:36,320 --> 00:12:34,020
exploring the Kuiper belt and they said

272
00:12:38,570 --> 00:12:36,330
we want to do more okay because this is

273
00:12:41,600 --> 00:12:38,580
actually the first mission to the Kuiper

274
00:12:44,270 --> 00:12:41,610
belt okay and they said please please

275
00:12:45,590 --> 00:12:44,280
can we do more and well NASA of course

276
00:12:49,460 --> 00:12:45,600
says well what are you gonna look at

277
00:12:52,790 --> 00:12:49,470
they go oh yeah okay Hubble can you help

278
00:12:54,680 --> 00:12:52,800
us so Hubble went and looked and Hubble

279
00:12:57,290 --> 00:12:54,690
went out and found a bunch of Kuiper

280
00:12:59,780 --> 00:12:57,300
belt objects these ones in the green

281
00:13:01,730 --> 00:12:59,790
circles here this is the motion of those

282
00:13:03,440 --> 00:13:01,740
objects over a period of time

283
00:13:05,390 --> 00:13:03,450
that's how Hubble finds things in the

284
00:13:07,280 --> 00:13:05,400
solar system it just looks and anything

285
00:13:10,460 --> 00:13:07,290
that stays stationary is way distant

286
00:13:12,320 --> 00:13:10,470
anything that starts moving is inside

287
00:13:14,900 --> 00:13:12,330
the solar system it found a couple

288
00:13:17,090 --> 00:13:14,910

candidate Kuiper belt objects and

289
00:13:18,140 --> 00:13:17,100
eventually they found one that worked

290
00:13:19,820 --> 00:13:18,150
for the cut for the

291
00:13:21,590 --> 00:13:19,830
horizons mission so they didn't have to

292
00:13:25,070 --> 00:13:21,600
use too much fuel to steer towards it

293
00:13:28,490 --> 00:13:25,080
and appeared to be some object that

294
00:13:31,730 --> 00:13:28,500
might be of interest it was called 2014

295
00:13:36,080 --> 00:13:31,740
mu 69 yeah that just rolls off the

296
00:13:37,640 --> 00:13:36,090
tongue 2014 mu 69 yes so the folks who

297
00:13:39,260 --> 00:13:37,650
run the mission said you know what we

298
00:13:43,480 --> 00:13:39,270
want to give it a nickname they ran a

299
00:13:46,100 --> 00:13:43,490
contest and its nickname is old tomorrow

300
00:13:47,660 --> 00:13:46,110
I have no idea if that's how you

301
00:13:49,130 --> 00:13:47,670
pronounce it I was supposed to be

302
00:13:52,450 --> 00:13:49,140
pronounced but it's just so much fun to

303
00:13:56,150 --> 00:13:52,460
say it's a tumor

304
00:14:01,450 --> 00:13:56,160
so they redirected the mission to pass

305
00:14:06,980 --> 00:14:01,460
by 2014 and you 69 when on January 1st

306
00:14:09,110 --> 00:14:06,990
2019 but they still wanted to know what

307
00:14:11,180 --> 00:14:09,120
they were going to go if they were going

308
00:14:13,040 --> 00:14:11,190
to find they had guys with Pluto we had

309
00:14:14,750 --> 00:14:13,050
you know 60 years of observations to

310
00:14:16,550 --> 00:14:14,760
understand what we were gonna find we

311
00:14:19,130 --> 00:14:16,560
had almost no observations you saw the

312
00:14:23,300 --> 00:14:19,140
dots right yeah it doesn't tell you much

313
00:14:26,600 --> 00:14:23,310

so what they did is they went around the

314
00:14:29,930 --> 00:14:26,610
globe and they found places where mu 69

315
00:14:32,090 --> 00:14:29,940
would actually occult a star alright and

316
00:14:33,860 --> 00:14:32,100
the stars light would drop when it

317
00:14:37,550 --> 00:14:33,870
passed it over and then rise back up and

318
00:14:40,550 --> 00:14:37,560
so they actually had teams at different

319
00:14:43,220 --> 00:14:40,560
latitudes watching during the

320
00:14:45,440 --> 00:14:43,230
occultation and those down here didn't

321
00:14:47,960 --> 00:14:45,450
see any occultation those up here didn't

322
00:14:49,220 --> 00:14:47,970
see any occultation here it's they saw

323
00:14:52,160 --> 00:14:49,230
an authorization from here to here here

324
00:14:55,790 --> 00:14:52,170
to here here to here and what you get is

325
00:14:58,940 --> 00:14:55,800
an actual map of the shape of Ultima

326
00:15:01,580 --> 00:14:58,950
Thule on the earth from the occupations

327
00:15:03,740 --> 00:15:01,590
they went down and they map out the

328
00:15:07,850 --> 00:15:03,750
shape the expected shape multi-mode too

329
00:15:09,650 --> 00:15:07,860
late using occultation x' an amazing

330
00:15:12,350 --> 00:15:09,660
work mark view he gave a talk here a few

331
00:15:15,410 --> 00:15:12,360
weeks ago and he actually was so

332
00:15:17,660 --> 00:15:15,420
confident this he made a 3d model of

333
00:15:21,200 --> 00:15:17,670
what he expected Ultima Thule to look

334
00:15:23,540 --> 00:15:21,210
like before the encounter and when the

335
00:15:27,160 --> 00:15:23,550
encounter happened here he is showing

336
00:15:31,350 --> 00:15:27,170
his model against the observations

337
00:15:34,030 --> 00:15:31,360
is this guy good or what okay

338
00:15:36,730 --> 00:15:34,040

unbelievable that a predicted very

339
00:15:39,250 --> 00:15:36,740
accurately using these occupations the

340
00:15:41,800 --> 00:15:39,260
shape of Ultima Thule that's one of the

341
00:15:43,720 --> 00:15:41,810
low resolutions image from Lori on the

342
00:15:46,800 --> 00:15:43,730
way in but when they had time to get

343
00:15:50,769 --> 00:15:46,810
more data here's what it looked like

344
00:15:54,100 --> 00:15:50,779
that is our that is our snowman in the

345
00:15:56,650 --> 00:15:54,110
Kuiper belt basically it is a contact

346
00:15:59,319 --> 00:15:56,660
binary why I call um so it means that

347
00:16:01,870 --> 00:15:59,329
this object here and this object here

348
00:16:05,110 --> 00:16:01,880
obviously formed separately but then

349
00:16:07,210 --> 00:16:05,120
Smok together like two snowballs and

350
00:16:09,519 --> 00:16:07,220
formed a snowman that's floating around

351
00:16:13,329 --> 00:16:09,529
in the Kuiper belt four billion miles

352
00:16:16,360 --> 00:16:13,339
away from you and the real hope here is

353
00:16:18,069 --> 00:16:16,370
that the study of this will teach us a

354
00:16:20,199 --> 00:16:18,079
bit about the early solar system because

355
00:16:22,420 --> 00:16:20,209
when we have comets that come into the

356
00:16:25,720 --> 00:16:22,430
inner solar system they melt and that

357
00:16:28,690 --> 00:16:25,730
gases flow away the ices flow away and

358
00:16:30,850 --> 00:16:28,700
they've been changed a lot this object

359
00:16:34,030 --> 00:16:30,860
hopefully it's sitting out there in the

360
00:16:36,939 --> 00:16:34,040
main Kuiper belt out it's you know what

361
00:16:40,210 --> 00:16:36,949
40 astronomical units away probably has

362
00:16:41,439 --> 00:16:40,220
not undergone that much change in its in

363
00:16:44,319 --> 00:16:41,449

the four and half billion year history

364
00:16:47,530 --> 00:16:44,329
of the solar system so the hope is when

365
00:16:49,420 --> 00:16:47,540
they study what the surface of the

366
00:16:51,579 --> 00:16:49,430
information from the surface of this

367
00:16:53,560 --> 00:16:51,589
that they will begin to understand a bit

368
00:16:56,560 --> 00:16:53,570
about the proto solar nebula and the

369
00:16:59,949 --> 00:16:56,570
initial composition of the objects that

370
00:17:01,720 --> 00:16:59,959
formed in the solar system okay and just

371
00:17:04,150 --> 00:17:01,730
because it's contact binary and they

372
00:17:07,210 --> 00:17:04,160
could they nicknamed the small one Thule

373
00:17:08,710 --> 00:17:07,220
and the large one Ultima okay so our

374
00:17:11,020 --> 00:17:08,720
snowman has has a nickname

375
00:17:14,110 --> 00:17:11,030
well not call him parson brown we'll

376
00:17:16,929 --> 00:17:14,120
call them Ultima Thule all right and

377
00:17:20,140 --> 00:17:16,939
just for comparison here is that same

378
00:17:22,390 --> 00:17:20,150
image of Ultima Thule compared to comet

379
00:17:24,760 --> 00:17:22,400
nuclei the most famous being this is the

380
00:17:27,280 --> 00:17:24,770
nuclei of comet Halley it's nine point

381
00:17:30,880 --> 00:17:27,290
three miles across where this is 21

382
00:17:33,570 --> 00:17:30,890
miles across okay temple morally wild

383
00:17:36,430 --> 00:17:33,580
and Hartley 2 you can see it has these

384
00:17:38,380 --> 00:17:36,440
interesting shapes and that's really

385
00:17:39,120 --> 00:17:38,390
what the most of the objects in the

386
00:17:41,910 --> 00:17:39,130
Kuiper belt

387
00:17:43,740 --> 00:17:41,920
are they are what would be comet nuclei

388
00:17:46,350 --> 00:17:43,750

but they're way out at the edge of the

389
00:17:48,330 --> 00:17:46,360
solar system their icy and slightly

390
00:17:50,220 --> 00:17:48,340
rocky objects that if they got kicked

391
00:17:52,800 --> 00:17:50,230
into the inner solar system they would

392
00:17:54,480 --> 00:17:52,810
become comets okay so they're I guess

393
00:17:58,050 --> 00:17:54,490
you can call it a dormant commentary

394
00:18:00,060 --> 00:17:58,060
nuclei however this one being out there

395
00:18:02,880 --> 00:18:00,070
for all things hopefully it will teach

396
00:18:04,710 --> 00:18:02,890
us about the pristine solar system where

397
00:18:07,470 --> 00:18:04,720
all the things on the right teaches us

398
00:18:09,950 --> 00:18:07,480
about the solar system as its evolved

399
00:18:13,440 --> 00:18:09,960
through and over time and changed yeah

400
00:18:16,320 --> 00:18:13,450
so that was our new year's resolution

401
00:18:23,730 --> 00:18:16,330
that we got resolution of Ultima Thule

402
00:18:25,800 --> 00:18:23,740
an astronomy yes yeah like five thousand

403
00:18:28,530 --> 00:18:25,810
miles or something like that I can't I

404
00:18:31,950 --> 00:18:28,540
mean this is not the highest resolution

405
00:18:35,910 --> 00:18:31,960
image it will have back the data rate

406
00:18:41,270 --> 00:18:35,920
from deep from 40 astronomical units is

407
00:18:46,620 --> 00:18:44,070
yeah I mean we're getting bits per

408
00:18:49,230 --> 00:18:46,630
second not kilobits per second okay not

409
00:18:53,610 --> 00:18:49,240
even megabits per second it's per second

410
00:18:55,080 --> 00:18:53,620
type data rate so it will take 14 months

411
00:18:58,140 --> 00:18:55,090
for all of the data from the encounter

412
00:19:02,100 --> 00:18:58,150
to get down okay so they'll get some

413
00:19:04,050 --> 00:19:02,110

really good stuff starting soon it went

414
00:19:05,490 --> 00:19:04,060
behind the Sun in art from our

415
00:19:07,260 --> 00:19:05,500
perspective so we couldn't get data for

416
00:19:10,350 --> 00:19:07,270
a while it's now back they're starting

417
00:19:12,450 --> 00:19:10,360
to get the data coming down so be

418
00:19:18,150 --> 00:19:12,460
patient we'll know more about this in

419
00:19:27,510 --> 00:19:18,160
six to nine months like it does not

420
00:19:30,600 --> 00:19:27,520
shine on its own 48 48 you yes contact

421
00:19:33,270 --> 00:19:30,610
like the Jupiter kept things from

422
00:19:37,220 --> 00:19:33,280
forming Mars

423
00:19:41,370 --> 00:19:37,230
any planetary formations may be gone

424
00:19:43,110 --> 00:19:41,380
well the Kuiper belt at least the inner

425
00:19:45,810 --> 00:19:43,120
edge of it is heavily governed by

426
00:19:47,760 --> 00:19:45,820
Neptune's mass Neptune's at 38 you and

427
00:19:50,370 --> 00:19:47,770
we have a strong cutoff in the

428
00:19:52,169 --> 00:19:50,380
distribution of objects at 30 au there's

429
00:19:56,220 --> 00:19:52,179
also a strong cutoff

430
00:19:57,649 --> 00:19:56,230
da you and that's not as fully explained

431
00:20:00,960 --> 00:19:57,659
okay

432
00:20:03,210 --> 00:20:00,970
there could be another planetary type

433
00:20:05,759 --> 00:20:03,220
object folks know that there's a search

434
00:20:07,379 --> 00:20:05,769
on for Planet nine but that's in a

435
00:20:09,149 --> 00:20:07,389
totally different orbit I'm not sure

436
00:20:11,299 --> 00:20:09,159
that would affect the 50 au

437
00:20:16,350 --> 00:20:11,309
cutoff because that's way out there like

438
00:20:19,529 --> 00:20:16,360

7,500 au type thing I'm not a Kuiper

439
00:20:21,810 --> 00:20:19,539
belt specialist but I know in talking to

440
00:20:22,830 --> 00:20:21,820
one of them Mike Brown was a hit on went

441
00:20:24,600 --> 00:20:22,840
to graduate school together

442
00:20:28,560 --> 00:20:24,610
he was like no there really is a strong

443
00:20:30,029 --> 00:20:28,570
cutoff around 50 au and usually there's

444
00:20:32,609 --> 00:20:30,039
some gravitational interaction that will

445
00:20:35,369 --> 00:20:32,619
stop that will cause that I don't know

446
00:20:41,549 --> 00:20:35,379
one but maybe I'm just ignorant on that

447
00:20:44,340 --> 00:20:41,559
okay yes okay how does the Oort cloud

448
00:20:47,369 --> 00:20:44,350
relate to the area so the Kuiper belt is

449
00:20:49,230 --> 00:20:47,379
in the plane of the solar system and

450
00:20:52,350 --> 00:20:49,240
it's a it's a belt it's it's it's fluffy

451
00:20:55,440 --> 00:20:52,360
but it's it's mostly flat okay and that

452
00:20:57,869 --> 00:20:55,450
goes out thirty to fifty au Oort cloud

453
00:21:01,019 --> 00:20:57,879
is much much much much much bigger it

454
00:21:04,259 --> 00:21:01,029
starts around 2000 au and goes out to

455
00:21:06,419 --> 00:21:04,269
maybe 50,000 au and that's roughly

456
00:21:10,139 --> 00:21:06,429
spherical okay

457
00:21:12,560 --> 00:21:10,149
and the whereas the the Kuiper belt is

458
00:21:15,450 --> 00:21:12,570
the genesis of the short period comets

459
00:21:18,899 --> 00:21:15,460
the Oort cloud is the genesis of a long

460
00:21:20,100 --> 00:21:18,909
period comets comets that are more than

461
00:21:22,409 --> 00:21:20,110
200 years are called

462
00:21:24,180 --> 00:21:22,419
long period comets that have orbits less

463
00:21:26,940 --> 00:21:24,190

than 200 years are called short period

464
00:21:28,470 --> 00:21:26,950
comets so we believe the reservoir of

465
00:21:30,359 --> 00:21:28,480
where the short period comets come from

466
00:21:33,600 --> 00:21:30,369
is the Kuiper belt the long period

467
00:21:35,159 --> 00:21:33,610
comets come from the Oort cloud and a

468
00:21:37,139 --> 00:21:35,169
lot of the Oort cloud things basically

469
00:21:39,210 --> 00:21:37,149
how they got out there was there they're

470
00:21:45,029 --> 00:21:39,220
scattered out of a solar system by

471
00:21:47,039 --> 00:21:45,039
Jupiter I don't want to take up too much

472
00:21:49,409 --> 00:21:47,049
of Scott's time if you have more

473
00:21:57,490 --> 00:21:49,419
questions you can come down and ask me

474
00:22:08,750 --> 00:22:07,669
okay so are we up I'm gonna let you

475
00:22:10,610 --> 00:22:08,760
introduce yourself because I've already

476
00:22:12,620 --> 00:22:10,620
talked way too long here ladies and

477
00:22:14,269 --> 00:22:12,630
gentlemen the incredible the inimitable

478
00:22:23,389 --> 00:22:14,279
he's gonna talk about some really cool

479
00:22:24,289 --> 00:22:23,399
things dr. Scott Fleming thank you very

480
00:22:27,139 --> 00:22:24,299
much everyone

481
00:22:30,379 --> 00:22:27,149
looks like my mikes good so I want to

482
00:22:32,480 --> 00:22:30,389
echo Frank's thanks for all you coming

483
00:22:36,409 --> 00:22:32,490
out on a cold night in January to hear

484
00:22:38,060 --> 00:22:36,419
about a very new mission Tess and also I

485
00:22:41,240 --> 00:22:38,070
want to say hello and welcome to people

486
00:22:45,640 --> 00:22:41,250
watching online I also want to thank

487
00:22:47,379 --> 00:22:45,650
Frank for a fantastic my accident

488
00:22:49,850 --> 00:22:47,389

[Applause]

489
00:22:51,590 --> 00:22:49,860
background information on comets and

490
00:22:53,000 --> 00:22:51,600
clusters because believe it or not even

491
00:22:54,590 --> 00:22:53,010
though I'll be presenting the most

492
00:22:56,629 --> 00:22:54,600
exciting results on exoplanets I have

493
00:22:59,990 --> 00:22:56,639
slides involving clusters and comets as

494
00:23:02,500 --> 00:23:00,000
well so now that was a fantastic job so

495
00:23:04,940 --> 00:23:02,510
tonight I'll be sharing with you some

496
00:23:07,070 --> 00:23:04,950
information on the test spacecraft I

497
00:23:09,980 --> 00:23:07,080
figured I would start by describing the

498
00:23:12,169 --> 00:23:09,990
spacecraft and showing explaining what

499
00:23:14,720 --> 00:23:12,179
the spacecrafts doing now and how it's

500
00:23:16,940 --> 00:23:14,730
doing it's science I'll do a very quick

501
00:23:18,830 --> 00:23:16,950
summary of some of the very early

502
00:23:21,259 --> 00:23:18,840
results and I'll highlight with the

503
00:23:23,450 --> 00:23:21,269
first three exoplanets the test has not

504
00:23:27,409 --> 00:23:23,460
only found but confirmed to be actual

505
00:23:31,430 --> 00:23:27,419
objects first though some boring stuff

506
00:23:33,139 --> 00:23:31,440
me I figured I would introduce myself a

507
00:23:34,850 --> 00:23:33,149
little bit because space telescopes very

508
00:23:36,799 --> 00:23:34,860
large there's more than five hundred and

509
00:23:38,990 --> 00:23:36,809
some-odd people here at the minimum it's

510
00:23:40,399 --> 00:23:39,000
growing it seems like everyday so I

511
00:23:42,320 --> 00:23:40,409
figured I'd explain what my role is here

512
00:23:44,779 --> 00:23:42,330
at Space Telescope before we get into

513
00:23:46,700 --> 00:23:44,789

the mission so Space Telescope does a

514
00:23:48,440 --> 00:23:46,710
number of things most of you probably

515
00:23:49,610 --> 00:23:48,450
know that we're the science operations

516
00:23:51,440 --> 00:23:49,620
center for the Hubble Space Telescope

517
00:23:54,019 --> 00:23:51,450
we're going to be the Operations Center

518
00:23:56,960 --> 00:23:54,029
for the James Webb Space Telescope we

519
00:23:58,669 --> 00:23:56,970
have an outreach department that does a

520
00:24:00,409 --> 00:23:58,679
lot to communicate a lot of the science

521
00:24:02,360 --> 00:24:00,419
results being discovered by telescopes

522
00:24:04,879 --> 00:24:02,370
we have a lot of software developers who

523
00:24:07,560 --> 00:24:04,889
are making astronomy software for

524
00:24:09,150 --> 00:24:07,570
astronomers to use to analyze data

525
00:24:11,790 --> 00:24:09,160
another thing we do is actually serve as

526
00:24:15,120 --> 00:24:11,800
an archive which is where I work for

527
00:24:17,400 --> 00:24:15,130
data from a variety of missions so I

528
00:24:18,720 --> 00:24:17,410
work at the Mikulski archive for Space

529
00:24:21,660 --> 00:24:18,730
Telescope's it's part of the Space

530
00:24:24,270 --> 00:24:21,670
Telescope Science Institute and it

531
00:24:26,550 --> 00:24:24,280
actually has data from more than 20

532
00:24:30,360 --> 00:24:26,560
different missions most of them NASA

533
00:24:33,090 --> 00:24:30,370
missions that flew in space we have data

534
00:24:35,100 --> 00:24:33,100
ranging all the way from the 1970s with

535
00:24:38,820 --> 00:24:35,110
the International ultraviolet Explorer

536
00:24:42,120 --> 00:24:38,830
all the way to tests now which just had

537
00:24:43,980 --> 00:24:42,130
its first data release six weeks ago so

538
00:24:45,780 --> 00:24:43,990

part of my job working with more than 30

539
00:24:48,510 --> 00:24:45,790
different astronomers developers and

540
00:24:51,390 --> 00:24:48,520
engineers in my branch is to make sure

541
00:24:53,310 --> 00:24:51,400
that all this data are kept not only for

542
00:24:55,770 --> 00:24:53,320
a few weeks or a few years but for

543
00:24:58,320 --> 00:24:55,780
decades and available for people all

544
00:25:00,830 --> 00:24:58,330
around the world to make use of from all

545
00:25:03,450 --> 00:25:00,840
these different missions that we collect

546
00:25:05,810 --> 00:25:03,460
so let's talk about test it wouldn't be

547
00:25:07,980 --> 00:25:05,820
a NASA mission without in acronyms and

548
00:25:09,660 --> 00:25:07,990
tests is indeed an acronym it's not as

549
00:25:12,360 --> 00:25:09,670
far as I know named after an individual

550
00:25:14,970 --> 00:25:12,370
it stands for the transiting exoplanet

551
00:25:17,850 --> 00:25:14,980
survey satellite and in fact the acronym

552
00:25:19,890 --> 00:25:17,860
is a great summary of what test is it's

553
00:25:22,350 --> 00:25:19,900
a satellite it's a specific specifically

554
00:25:25,470 --> 00:25:22,360
a Space Telescope conducting a survey

555
00:25:28,200 --> 00:25:25,480
for transiting exoplanets and I refer to

556
00:25:30,720 --> 00:25:28,210
the word exoplanet or extrasolar planet

557
00:25:33,320 --> 00:25:30,730
what I'm referring to our planets

558
00:25:35,400 --> 00:25:33,330
orbiting stars outside our solar system

559
00:25:37,440 --> 00:25:35,410
just so that everyone's clear and what I

560
00:25:40,140 --> 00:25:37,450
mean by that there's a couple of primary

561
00:25:43,320 --> 00:25:40,150
science objectives one of them is to

562
00:25:47,310 --> 00:25:43,330
search more than 200,000 nearby stars to

563
00:25:48,840 --> 00:25:47,320

detect new extrasolar planets and the

564
00:25:50,510 --> 00:25:48,850
key word is nearby and we'll talk about

565
00:25:53,700 --> 00:25:50,520
that more toward the ends of the talk

566
00:25:57,120 --> 00:25:53,710
another objective is using ground-based

567
00:25:59,280 --> 00:25:57,130
follow-up data to measure the masses for

568
00:26:00,840 --> 00:25:59,290
at least 50 planets that are smaller

569
00:26:03,300 --> 00:26:00,850
than about four times the size of the

570
00:26:05,910 --> 00:26:03,310
earth that's another objective and the

571
00:26:08,730 --> 00:26:05,920
third objective is actually to play a

572
00:26:11,030 --> 00:26:08,740
sort of in collaboration with the James

573
00:26:14,760 --> 00:26:11,040
Webb Space Telescope tests will identify

574
00:26:17,760 --> 00:26:14,770
some of the best exoplanets orbiting the

575
00:26:19,830 --> 00:26:17,770
brightest nearby stars so that when

576
00:26:21,420 --> 00:26:19,840
James Webb launches in a couple of years

577
00:26:24,090 --> 00:26:21,430
it will be able

578
00:26:27,510 --> 00:26:24,100
to do one of its key science drivers to

579
00:26:29,130 --> 00:26:27,520
not only study the exoplanets as a whole

580
00:26:31,680 --> 00:26:29,140
but to measure some of their chemical

581
00:26:33,720 --> 00:26:31,690
compositions in their atmospheres a very

582
00:26:35,730 --> 00:26:33,730
challenging measurement one that we have

583
00:26:37,800 --> 00:26:35,740
done from the ground and even with

584
00:26:40,260 --> 00:26:37,810
Hubble Space Telescope but James Webb

585
00:26:42,360 --> 00:26:40,270
because of the size and the type of data

586
00:26:45,120 --> 00:26:42,370
that will get will revolutionize our

587
00:26:45,900 --> 00:26:45,130
ability to not only detect planets

588
00:26:48,450 --> 00:26:45,910

around other stars

589
00:26:51,510 --> 00:26:48,460
but measure what their atmospheres are

590
00:26:53,340 --> 00:26:51,520
like and this is a key step in

591
00:26:57,720 --> 00:26:53,350
understanding the broader question of

592
00:26:59,970 --> 00:26:57,730
life in our universe real quick there's

593
00:27:02,790 --> 00:26:59,980
a variety of institutions involved in

594
00:27:05,970 --> 00:27:02,800
the mission the science operations are

595
00:27:09,030 --> 00:27:05,980
controlled by primarily MIT and Harvard

596
00:27:11,040 --> 00:27:09,040
but there are also dozens of astronomers

597
00:27:12,660 --> 00:27:11,050
in dozens of institutions around the

598
00:27:14,930 --> 00:27:12,670
world working together to do the science

599
00:27:18,540 --> 00:27:14,940
operations of the spacecraft spacecraft

600
00:27:20,520 --> 00:27:18,550
Northrop Grumman was responsible for the

601
00:27:23,570 --> 00:27:20,530
sort of the the payload and engineering

602
00:27:25,560 --> 00:27:23,580
parts of it and then Space Telescope

603
00:27:27,000 --> 00:27:25,570
working with our friends at the NASA

604
00:27:29,970 --> 00:27:27,010
exoplanet Science Institute in

605
00:27:32,070 --> 00:27:29,980
California serve as the archives the

606
00:27:34,110 --> 00:27:32,080
final resting place for this valuable

607
00:27:37,440 --> 00:27:34,120
data the spacecraft is collecting

608
00:27:39,510 --> 00:27:37,450
downloading and being made public so I

609
00:27:47,640 --> 00:27:39,520
had to start with one of my favorite

610
00:27:54,590 --> 00:27:47,650
things still a launch eight seven six

611
00:27:56,510 --> 00:27:54,600
five four three two one zero

612
00:27:59,900 --> 00:27:56,520
[Applause]

613
00:28:02,240 --> 00:27:59,910

liftoff the SpaceX Falcon 9 carrying

614
00:28:04,190 --> 00:28:02,250
tests a planet-hunting spacecraft that

615
00:28:06,380 --> 00:28:04,200
will search for new worlds beyond our

616
00:28:08,419 --> 00:28:06,390
solar system so that was just a quick

617
00:28:12,290 --> 00:28:08,429
clip of the launch which happened in

618
00:28:14,630 --> 00:28:12,300
April just about a few months ago it was

619
00:28:17,180 --> 00:28:14,640
a nearly flawless launch by SpaceX it

620
00:28:19,669 --> 00:28:17,190
was actually the first time SpaceX

621
00:28:23,030 --> 00:28:19,679
launched a science telescope for NASA

622
00:28:25,400 --> 00:28:23,040
previously most if not all of its supply

623
00:28:28,280 --> 00:28:25,410
missions had been deliveries to the

624
00:28:31,790 --> 00:28:28,290
International Space Station but it was a

625
00:28:35,210 --> 00:28:31,800
perfect launch and the spacecraft is is

626
00:28:36,950 --> 00:28:35,220
healthy and in a great spot but there's

627
00:28:38,450 --> 00:28:36,960
a second launch and that's when this is

628
00:28:40,460 --> 00:28:38,460
where we come in this is when the data

629
00:28:43,299 --> 00:28:40,470
go public so this is some social media

630
00:28:46,460 --> 00:28:43,309
tweets that I collected in my scrapbook

631
00:28:48,590 --> 00:28:46,470
we had the first launch of data from the

632
00:28:51,860 --> 00:28:48,600
test mission to the astronomical

633
00:28:55,100 --> 00:28:51,870
community just this past December just

634
00:28:56,870 --> 00:28:55,110
about about six weeks ago you can see

635
00:29:00,320 --> 00:28:56,880
some people were trying to call it test

636
00:29:03,740 --> 00:29:00,330
miss since it happened a few weeks

637
00:29:06,230 --> 00:29:03,750
before Christmas and people were hungry

638
00:29:08,810 --> 00:29:06,240

for this data you can see people

639
00:29:11,510 --> 00:29:08,820
tweeting their screenshots of the page I

640
00:29:13,100 --> 00:29:11,520
wrote with their coffee say where is it

641
00:29:16,490 --> 00:29:13,110
and I'm saying it's come in give me a

642
00:29:19,780 --> 00:29:16,500
second December 6th was very busy for us

643
00:29:21,770 --> 00:29:19,790
but everything went successfully

644
00:29:24,200 --> 00:29:21,780
astronomers around the world we're

645
00:29:26,330 --> 00:29:24,210
waiting for this if as anybody heard the

646
00:29:28,460 --> 00:29:26,340
Zooniverse project or planet hunters or

647
00:29:30,470 --> 00:29:28,470
any of the citizen science projects and

648
00:29:33,410 --> 00:29:30,480
in the past if any of you are familiar

649
00:29:37,370 --> 00:29:33,420
with those there's a group in Oxford in

650
00:29:40,630 --> 00:29:37,380
Finland who are making the data public

651
00:29:44,030 --> 00:29:40,640
for citizen scientists to be able to

652
00:29:45,860 --> 00:29:44,040
look at the data and help us classify

653
00:29:47,480 --> 00:29:45,870
all the interesting signals and they

654
00:29:50,240 --> 00:29:47,490
were able to download data from us and

655
00:29:52,070 --> 00:29:50,250
get data in there sort of interface on

656
00:29:54,500 --> 00:29:52,080
the web for citizen scientists to look

657
00:29:55,910 --> 00:29:54,510
at within four hours of us going live

658
00:29:58,820 --> 00:29:55,920
it's a record

659
00:30:00,620 --> 00:29:58,830
it's amazing other fun stuff about a

660
00:30:04,580 --> 00:30:00,630
week later this is where the comets come

661
00:30:05,690 --> 00:30:04,590
in some group at Washington was trying

662
00:30:08,130 --> 00:30:05,700
to figure out what's going on with one

663
00:30:11,670 --> 00:30:08,140

particular star and this poor star

664
00:30:13,230 --> 00:30:11,680
not only does it end up having it's

665
00:30:15,690 --> 00:30:13,240
sitting there trying to you know shine

666
00:30:17,760 --> 00:30:15,700
and measure its brightness but what they

667
00:30:20,820 --> 00:30:17,770
found was not only does this star have

668
00:30:23,100 --> 00:30:20,830
one after I come across and sort of get

669
00:30:25,050 --> 00:30:23,110
in the way but then later during the

670
00:30:27,750 --> 00:30:25,060
same observation a completely

671
00:30:29,960 --> 00:30:27,760
independent and second asteroid comes

672
00:30:32,640 --> 00:30:29,970
across right in from the starker and

673
00:30:34,740 --> 00:30:32,650
ruins their ability to measure the the

674
00:30:36,270 --> 00:30:34,750
flux of the star but the bonus science

675
00:30:37,650 --> 00:30:36,280
is people interested in studying comets

676
00:30:40,770 --> 00:30:37,660
and asteroids get all these nice

677
00:30:44,220 --> 00:30:40,780
pictures to be able to study asteroids

678
00:30:47,370 --> 00:30:44,230
and comets so it was a fantastic launch

679
00:30:49,230 --> 00:30:47,380
in the first week we estimate we

680
00:30:51,930 --> 00:30:49,240
delivered at least a hundred terabytes

681
00:30:56,150 --> 00:30:51,940
of test data to more than 950

682
00:31:01,500 --> 00:30:58,950
let's go back to the spacecraft this is

683
00:31:03,690 --> 00:31:01,510
a movie that shows where tests how tests

684
00:31:06,690 --> 00:31:03,700
sort of orbits around the earth which is

685
00:31:10,290 --> 00:31:06,700
located here in the center of your of

686
00:31:13,080 --> 00:31:10,300
your screen and then the moon is this

687
00:31:17,370 --> 00:31:13,090
gray orbit here and you'll notice that

688
00:31:18,810 --> 00:31:17,380

Tests orbits inclined relative to the

689
00:31:21,210 --> 00:31:18,820
earth on the moon so it sort of dips

690
00:31:23,430 --> 00:31:21,220
above and below the plane of the Earth

691
00:31:24,990 --> 00:31:23,440
Moon system Wow the other thing you'll

692
00:31:27,000 --> 00:31:25,000
notice is that the orbit is not circular

693
00:31:29,460 --> 00:31:27,010
somewhat elliptical and this is by

694
00:31:32,910 --> 00:31:29,470
design it's actually a very stable orbit

695
00:31:35,250 --> 00:31:32,920
and during the blue parts of the orbit

696
00:31:36,900 --> 00:31:35,260
test is staring at one part of the sky

697
00:31:38,880 --> 00:31:36,910
collecting lots of data on the

698
00:31:41,070 --> 00:31:38,890
brightness of all the targets in its

699
00:31:44,070 --> 00:31:41,080
field of view and then when it dips down

700
00:31:48,180 --> 00:31:44,080
to the I'm sorry when it dips down to

701
00:31:50,430 --> 00:31:48,190
the orange part of the orbit it actually

702
00:31:54,810 --> 00:31:50,440
downloads its data to earth as fast as

703
00:31:57,900 --> 00:31:54,820
possible where the bandwidth between us

704
00:32:00,690 --> 00:31:57,910
and the radio stations is is maximized

705
00:32:03,780 --> 00:32:00,700
not quite as hard of a problem as New

706
00:32:06,360 --> 00:32:03,790
Horizons but there's a lot of data it

707
00:32:09,150 --> 00:32:06,370
takes about two weeks for the spacecraft

708
00:32:11,640 --> 00:32:09,160
to go all the way around one orbit so it

709
00:32:14,460 --> 00:32:11,650
does one pass downloads two weeks of

710
00:32:16,290 --> 00:32:14,470
data does another loop downloads two

711
00:32:18,780 --> 00:32:16,300
more weeks of data and then it moves on

712
00:32:21,330 --> 00:32:18,790
to a new part of the sky and currently

713
00:32:21,910 --> 00:32:21,340

Tess has just begun its seventh section

714
00:32:23,500 --> 00:32:21,920
of the sky

715
00:32:25,960 --> 00:32:23,510
so it's about halfway done with the

716
00:32:27,490 --> 00:32:25,970
first year of the two-year prime mission

717
00:32:35,950 --> 00:32:27,500
just so everyone's aware of what the

718
00:32:39,160 --> 00:32:35,960
status of the spacecraft mission that's

719
00:32:41,260 --> 00:32:39,170
Travis so here's the spacecraft you can

720
00:32:45,400 --> 00:32:41,270
see the solar panels on the on the ways

721
00:32:47,050 --> 00:32:45,410
the dome on the back is the radio that

722
00:32:49,210 --> 00:32:47,060
it uses to communicate with earth and

723
00:32:51,040 --> 00:32:49,220
download its data and the most important

724
00:32:54,970 --> 00:32:51,050
part of the spacecraft are these four

725
00:32:57,400 --> 00:32:54,980
cameras in the cone this is what Tess

726
00:33:00,910 --> 00:32:57,410
uses to measure all the fluxes and look

727
00:33:03,220 --> 00:33:00,920
for exoplanets how does it detect

728
00:33:06,670 --> 00:33:03,230
exoplanets it uses a technique called

729
00:33:08,650 --> 00:33:06,680
the transit method and conceptually it's

730
00:33:11,530 --> 00:33:08,660
one of the simplest ways we can discover

731
00:33:14,830 --> 00:33:11,540
new planets around stars we measure the

732
00:33:17,590 --> 00:33:14,840
brightness of stars very very very

733
00:33:19,720 --> 00:33:17,600
carefully and literally wait for an

734
00:33:23,320 --> 00:33:19,730
exoplanet to cross in front of it and

735
00:33:25,750 --> 00:33:23,330
get in the way the challenge is that the

736
00:33:28,120 --> 00:33:25,760
amount of light that a planet blocks is

737
00:33:31,240 --> 00:33:28,130
very very tiny so you have to be able to

738
00:33:33,640 --> 00:33:31,250

measure brightnesses of stars very very

739
00:33:35,350 --> 00:33:33,650
carefully it's taking decades of us to

740
00:33:37,440 --> 00:33:35,360
get to where we are today but we're able

741
00:33:39,820 --> 00:33:37,450
to do so with a lot of great success

742
00:33:41,680 --> 00:33:39,830
you'll notice in this animation there's

743
00:33:43,060 --> 00:33:41,690
two different planets sort of as to show

744
00:33:44,530 --> 00:33:43,070
you what what the signals might look

745
00:33:45,880 --> 00:33:44,540
like this is sort of what happens if

746
00:33:47,740 --> 00:33:45,890
someone walks in front of a projector

747
00:33:49,450 --> 00:33:47,750
and a movie theater they'll block out

748
00:33:50,980 --> 00:33:49,460
part of the light and you'll see that

749
00:33:53,140 --> 00:33:50,990
the screen that was brightest somewhat

750
00:33:55,420 --> 00:33:53,150
less bright but you'll notice that we

751
00:33:57,640 --> 00:33:55,430
can actually model a lot of the

752
00:34:00,280 --> 00:33:57,650
interesting parts of a planetary system

753
00:34:03,400 --> 00:34:00,290
just by looking at the shape the depth

754
00:34:06,820 --> 00:34:03,410
of the transit decrease in brightness

755
00:34:09,340 --> 00:34:06,830
how long it lasts even details like the

756
00:34:11,980 --> 00:34:09,350
shapes of the beginning and ends can

757
00:34:17,260 --> 00:34:11,990
tell us a lot about the planets the

758
00:34:19,080 --> 00:34:17,270
Stars and the orbits of those planets so

759
00:34:21,610 --> 00:34:19,090
let's go back to the cameras real quick

760
00:34:24,460 --> 00:34:21,620
there's four of them like I mentioned in

761
00:34:26,980 --> 00:34:24,470
that count area and each one is

762
00:34:29,560 --> 00:34:26,990
surveying a large chunk of the sky I

763
00:34:31,210 --> 00:34:29,570

really want to focus on how big tessa is

764
00:34:33,580 --> 00:34:31,220
because it's very very different from

765
00:34:35,500 --> 00:34:33,590
other telescopes like Hubble each camera

766
00:34:37,870 --> 00:34:35,510
is 24 by 24

767
00:34:39,610 --> 00:34:37,880
Riis on the sky and there are four of

768
00:34:42,879 --> 00:34:39,620
them aligned so that they stack on top

769
00:34:44,919 --> 00:34:42,889
of each other on the sky so when Tess is

770
00:34:47,320 --> 00:34:44,929
collecting data it's quite really

771
00:34:50,919 --> 00:34:47,330
observing this orange wedge that's more

772
00:34:52,899 --> 00:34:50,929
than 90 degrees of the sky at a time so

773
00:34:55,570 --> 00:34:52,909
we'll do this with our four cameras for

774
00:34:58,210 --> 00:34:55,580
two weeks download the data do it again

775
00:35:00,550 --> 00:34:58,220
for two weeks and then after it's done

776
00:35:02,620 --> 00:35:00,560
with two orbits of collecting data with

777
00:35:04,870 --> 00:35:02,630
its cameras and it starts the next

778
00:35:07,030 --> 00:35:04,880
sector as we call it it will actually

779
00:35:11,050 --> 00:35:07,040
move a little bit on the sky and end up

780
00:35:13,630 --> 00:35:11,060
surveying this hemisphere on the sky so

781
00:35:15,790 --> 00:35:13,640
it'll take about one year to do the

782
00:35:18,160 --> 00:35:15,800
southern hemisphere starting sometime

783
00:35:20,260 --> 00:35:18,170
this summer it will finish the first

784
00:35:23,140 --> 00:35:20,270
year we'll literally flip around and

785
00:35:27,760 --> 00:35:23,150
we'll survey the northern part of the

786
00:35:30,490 --> 00:35:27,770
sky one key part to notice is that as

787
00:35:33,010 --> 00:35:30,500
its sweeping out and observing lots of

788
00:35:36,130 --> 00:35:33,020

stars along the sky one of the cameras

789
00:35:38,650 --> 00:35:36,140
camera number 4 actually stays in the

790
00:35:42,520 --> 00:35:38,660
same part of the sky every single time

791
00:35:44,620 --> 00:35:42,530
Tess observes this one camera is always

792
00:35:46,750 --> 00:35:44,630
going to be at the pole on the bottom

793
00:35:49,600 --> 00:35:46,760
and when it flips around to the north

794
00:35:52,990 --> 00:35:49,610
it'll be in the northern Pole this means

795
00:35:56,800 --> 00:35:53,000
that any target stars galaxies whatever

796
00:35:59,590 --> 00:35:56,810
that happen to lie in camera four will

797
00:36:02,950 --> 00:35:59,600
get observations every single month and

798
00:36:04,870 --> 00:36:02,960
will get a full year of continuous data

799
00:36:07,180 --> 00:36:04,880
we call this a continuous viewing zone

800
00:36:09,820 --> 00:36:07,190
and I bring it up because this sort of

801
00:36:12,330 --> 00:36:09,830
emphasizes the foresight of people

802
00:36:15,460 --> 00:36:12,340
planning tests working with James Webb

803
00:36:18,040 --> 00:36:15,470
because these continuous viewing zones

804
00:36:21,040 --> 00:36:18,050
that get a year of solid data in the

805
00:36:23,410 --> 00:36:21,050
north and south overlap with James

806
00:36:25,750 --> 00:36:23,420
Webb's continuous viewing zones and this

807
00:36:28,210 --> 00:36:25,760
was very much done on purpose so that

808
00:36:31,470 --> 00:36:28,220
when James Webb launches it will be able

809
00:36:34,480 --> 00:36:31,480
to observe any target in Tess's

810
00:36:37,180 --> 00:36:34,490
continuous viewing zones anytime the

811
00:36:39,520 --> 00:36:37,190
schedulers decide it makes sense this is

812
00:36:42,250 --> 00:36:39,530
an example of a synergy between tests

813
00:36:46,510 --> 00:36:42,260

the tiny planet finder and Webb the

814
00:36:46,850 --> 00:36:46,520
giant planet characterized er so this is

815
00:36:49,730 --> 00:36:46,860
well

816
00:36:52,340 --> 00:36:49,740
to do one more comparison with the with

817
00:36:54,110 --> 00:36:52,350
Hubble in this case and and tests so

818
00:36:56,140 --> 00:36:54,120
this is a picture of another star

819
00:36:59,210 --> 00:36:56,150
cluster Frank describes some of these

820
00:37:01,430 --> 00:36:59,220
clusters and before this particular

821
00:37:04,100 --> 00:37:01,440
image is a Hubble image of a cluster

822
00:37:06,200 --> 00:37:04,110
around the Large Magellanic Clouds this

823
00:37:07,520 --> 00:37:06,210
is a very nearby galaxy unlike some of

824
00:37:09,650 --> 00:37:07,530
the ones that Frank was talking about

825
00:37:12,230 --> 00:37:09,660
but it's still impressive that Hubble is

826
00:37:15,190 --> 00:37:12,240
able to actually resolve individual

827
00:37:18,260 --> 00:37:15,200
stars in this cluster around another

828
00:37:21,680 --> 00:37:18,270
calyx II albeit one that's very close to

829
00:37:24,800 --> 00:37:21,690
the Milky Way nevertheless to compare it

830
00:37:27,010 --> 00:37:24,810
for scale here's a picture taken from a

831
00:37:29,350 --> 00:37:27,020
ground-based telescope of the entire

832
00:37:31,790 --> 00:37:29,360
Magellanic galaxy so this is a

833
00:37:34,280 --> 00:37:31,800
neighboring companion galaxy to the note

834
00:37:37,070 --> 00:37:34,290
II Milky Way and what you previous

835
00:37:39,170 --> 00:37:37,080
previously saw in the Hubble image that

836
00:37:41,450 --> 00:37:39,180
I have since shrunk and stuck over here

837
00:37:43,550 --> 00:37:41,460
in the corner that nice beautiful

838
00:37:46,790 --> 00:37:43,560

picture of all these stars is really

839
00:37:49,700 --> 00:37:46,800
coming from just one little bright bump

840
00:37:52,040 --> 00:37:49,710
in this ground-based telescope picture

841
00:37:54,080 --> 00:37:52,050
of the entire galaxy all these bumps are

842
00:37:57,110 --> 00:37:54,090
things like stars and star formation

843
00:38:00,020 --> 00:37:57,120
regions and star clusters and a bunch of

844
00:38:02,240 --> 00:38:00,030
dust a lot of interesting structure so

845
00:38:04,190 --> 00:38:02,250
you can get a sense exactly how powerful

846
00:38:10,610 --> 00:38:04,200
the resolution is Hubble compared to the

847
00:38:13,220 --> 00:38:10,620
ground but test says hold my beer this

848
00:38:16,070 --> 00:38:13,230
is the four cameras from the first

849
00:38:19,100 --> 00:38:16,080
sector this is the entire Magellanic

850
00:38:22,670 --> 00:38:19,110
Cloud galaxies contained easily in one

851
00:38:26,660 --> 00:38:22,680
quarter of one of Tess's four cameras

852
00:38:29,300 --> 00:38:26,670
for scale this little blue over here in

853
00:38:32,390 --> 00:38:29,310
camera three is a small magellanic cloud

854
00:38:34,550 --> 00:38:32,400
and all of you seeing the little dot you

855
00:38:37,100 --> 00:38:34,560
see here every single one this is not

856
00:38:39,620 --> 00:38:37,110
noise these are not cosmic rays these

857
00:38:41,720 --> 00:38:39,630
are not television screen that cable

858
00:38:44,750 --> 00:38:41,730
went out on all they're saying the one

859
00:38:47,300 --> 00:38:44,760
is a star that might have a planet

860
00:38:49,730 --> 00:38:47,310
around it so you can see what the game

861
00:38:52,160 --> 00:38:49,740
the test is trying to play it's not

862
00:38:57,820 --> 00:38:52,170
going for high-definition it's going for

863
00:39:01,270 --> 00:38:57,830

screen size one last point on this

864
00:39:03,280 --> 00:39:01,280
this is the smallest dot I could small

865
00:39:06,790 --> 00:39:03,290
ask where I could draw with PowerPoint

866
00:39:09,460 --> 00:39:06,800
women let me draw a smaller one but this

867
00:39:11,950 --> 00:39:09,470
is supposed to represent this the area

868
00:39:15,670 --> 00:39:11,960
of sky that the Hubble Wide Field Camera

869
00:39:19,270 --> 00:39:15,680
3 now back in operation would see with

870
00:39:23,590 --> 00:39:19,280
its instrument the size of a test pixel

871
00:39:26,230 --> 00:39:23,600
on the sky is 525 times larger than the

872
00:39:31,750 --> 00:39:26,240
size of a woops III pixel on the sky and

873
00:39:34,780 --> 00:39:31,760
so that is this square so one pixel from

874
00:39:38,230 --> 00:39:34,790
Wide Field Camera 3 on Hubble is this

875
00:39:41,170 --> 00:39:38,240
much higher in the sky but on test one

876
00:39:43,330 --> 00:39:41,180
pixel from test is this much the sky

877
00:39:44,890 --> 00:39:43,340
they give you a sense and it's not

878
00:39:47,290 --> 00:39:44,900
really a game we're playing about which

879
00:39:49,630 --> 00:39:47,300
is better or worse they're different and

880
00:39:51,820 --> 00:39:49,640
for good reasons right I like to think

881
00:39:55,030 --> 00:39:51,830
of Hubble sort of operating like a

882
00:39:58,000 --> 00:39:55,040
powerful microscope does where it's

883
00:39:59,380 --> 00:39:58,010
being able to resolve and reveal things

884
00:40:01,420 --> 00:39:59,390
like tiny creatures in a drop of water

885
00:40:04,120 --> 00:40:01,430
while test is more like a surveyor

886
00:40:06,640 --> 00:40:04,130
that's really trying to chart the ocean

887
00:40:11,110 --> 00:40:06,650
itself different objectives different

888
00:40:13,180 --> 00:40:11,120

decisions on pixel sizes so let's go

889
00:40:15,700 --> 00:40:13,190
back to our first set of real data these

890
00:40:17,620 --> 00:40:15,710
are real images collected and downloaded

891
00:40:19,240 --> 00:40:17,630
and now public from the spacecraft you

892
00:40:22,720 --> 00:40:19,250
notice the Large Magellanic Cloud the

893
00:40:24,940 --> 00:40:22,730
small Magellanic Cloud lots of stars one

894
00:40:27,850 --> 00:40:24,950
of the things the bonus science that

895
00:40:30,040 --> 00:40:27,860
Tess is doing is that astronomers are

896
00:40:32,470 --> 00:40:30,050
looking at all kinds of other physics

897
00:40:35,380 --> 00:40:32,480
that are happening within these huge

898
00:40:38,230 --> 00:40:35,390
fields of view while Tess is looking for

899
00:40:39,760 --> 00:40:38,240
those transiting planets so I shared a

900
00:40:41,890 --> 00:40:39,770
couple of pictures of asteroids and

901
00:40:43,960 --> 00:40:41,900
comets there are going to be tons of

902
00:40:46,060 --> 00:40:43,970
asteroids and comets that astronomers

903
00:40:48,370 --> 00:40:46,070
will be analyzing from the test data

904
00:40:52,150 --> 00:40:48,380
another great example are supernovae

905
00:40:54,490 --> 00:40:52,160
exploding stars because Tess is staring

906
00:40:57,130 --> 00:40:54,500
at the sky and a huge part of the sky

907
00:40:59,440 --> 00:40:57,140
it doesn't care whether it's on time or

908
00:41:01,840 --> 00:40:59,450
late for a supernovae to happen it's

909
00:41:04,150 --> 00:41:01,850
just going to be in these huge fields of

910
00:41:06,160 --> 00:41:04,160
view and so one of the initial science

911
00:41:08,770 --> 00:41:06,170
results that were presented just last

912
00:41:11,770 --> 00:41:08,780
week at the double-a s were some of

913
00:41:14,650 --> 00:41:11,780

these supernovae that went off while

914
00:41:17,830 --> 00:41:14,660
test was observing there are actually

915
00:41:19,900 --> 00:41:17,840
six different supernovae that happened

916
00:41:22,900 --> 00:41:19,910
and discovered by telescopes on the

917
00:41:24,430 --> 00:41:22,910
ground specifically named the assassin

918
00:41:28,120 --> 00:41:24,440
survey which one of my favorite names

919
00:41:31,270 --> 00:41:28,130
for a survey and the Atlas survey and

920
00:41:33,850 --> 00:41:31,280
these telescopes found a supernovae by

921
00:41:35,740 --> 00:41:33,860
looking at relatively small parts of the

922
00:41:37,740 --> 00:41:35,750
sky compared to test and noticing that

923
00:41:41,050 --> 00:41:37,750
something here that wasn't there before

924
00:41:43,870 --> 00:41:41,060
and so they send out a alert to

925
00:41:45,520 --> 00:41:43,880
astronomers and so usually astronomers

926
00:41:47,890 --> 00:41:45,530
will rush to a telescope and try and get

927
00:41:49,690 --> 00:41:47,900
more data once the supernova happens but

928
00:41:52,360 --> 00:41:49,700
intestines cases don't worry about it

929
00:41:55,480 --> 00:41:52,370
I've been looking at this and everything

930
00:41:56,470 --> 00:41:55,490
else for a long time and so astronomers

931
00:41:59,350 --> 00:41:56,480
as soon as the data we're downloading

932
00:42:01,630 --> 00:41:59,360
are able to use the test light curves to

933
00:42:04,570 --> 00:42:01,640
get these beautiful plots of how the

934
00:42:05,950 --> 00:42:04,580
supernovae are changing over time this

935
00:42:10,300 --> 00:42:05,960
is just another example of what you can

936
00:42:12,070 --> 00:42:10,310
do with test data a lot of people

937
00:42:15,700 --> 00:42:12,080
probably heard of Kepler or k2

938
00:42:19,630 --> 00:42:15,710

I hope Kepler really revolutionized our

939
00:42:21,420 --> 00:42:19,640
understanding of exoplanets but the

940
00:42:25,210 --> 00:42:21,430
Kepler mission has since ended

941
00:42:28,030 --> 00:42:25,220
spacecraft was retired and shut down due

942
00:42:30,160 --> 00:42:28,040
to a loss of its gyros and the ability

943
00:42:32,350 --> 00:42:30,170
to control itself but it's really a

944
00:42:33,550 --> 00:42:32,360
bittersweet ending because the timing

945
00:42:35,950 --> 00:42:33,560
couldn't have been better it actually

946
00:42:38,740 --> 00:42:35,960
lasted much longer than the original

947
00:42:42,040 --> 00:42:38,750
mission was originally funded for and it

948
00:42:45,340 --> 00:42:42,050
ended not too long before tests started

949
00:42:47,110 --> 00:42:45,350
and so really Kepler and k2 are sort of

950
00:42:49,450 --> 00:42:47,120
that mission sort of passing the

951
00:42:51,220 --> 00:42:49,460
exoplanet torch to the next NASA mission

952
00:42:53,800 --> 00:42:51,230
which is tests and I mean that quite

953
00:42:56,350 --> 00:42:53,810
literally because the test data

954
00:42:59,200 --> 00:42:56,360
reduction pipeline is actually mostly

955
00:43:00,760 --> 00:42:59,210
the Kepler pipeline with tweets that's

956
00:43:06,430 --> 00:43:00,770
how much Kepler revolutionized our

957
00:43:08,530 --> 00:43:06,440
ability to measure these planets just to

958
00:43:11,590 --> 00:43:08,540
highlight again the impact Kepler had

959
00:43:13,900 --> 00:43:11,600
this is a little cartoon that sort of

960
00:43:17,370 --> 00:43:13,910
shows all the multi-planet systems

961
00:43:20,110 --> 00:43:17,380
Kepler found over its four plus years of

962
00:43:22,720 --> 00:43:20,120
operations and you can see it discovered

963
00:43:25,240 --> 00:43:22,730

all kinds of interesting planetary

964
00:43:25,690 --> 00:43:25,250
systems some of them having two planets

965
00:43:29,100 --> 00:43:25,700
some one

966
00:43:31,180 --> 00:43:29,110
four or five six different sizes

967
00:43:34,450 --> 00:43:31,190
different distances from their host

968
00:43:39,040 --> 00:43:34,460
stars and it's just really a cornucopia

969
00:43:41,050 --> 00:43:39,050
of exoplanets that were detected by the

970
00:43:43,690 --> 00:43:41,060
Kepler and then later the k2 mission

971
00:43:49,210 --> 00:43:43,700
which was sort of Kepler recycled you

972
00:43:51,700 --> 00:43:49,220
will but test is going to really go one

973
00:43:55,000 --> 00:43:51,710
step further so this is the Kepler field

974
00:43:57,610 --> 00:43:55,010
of view in yellow that's one camera from

975
00:43:59,560 --> 00:43:57,620
Tess one camera is twice the size of

976
00:44:01,630 --> 00:43:59,570
Kepler's entire field of view there's

977
00:44:04,270 --> 00:44:01,640
four of them for every single wedge

978
00:44:06,550 --> 00:44:04,280
every month we get basically eight times

979
00:44:10,330 --> 00:44:06,560
the size of Kepler we're good to up for

980
00:44:13,390 --> 00:44:10,340
two years across the entire sky so while

981
00:44:17,470 --> 00:44:13,400
Kepler detected a lot of exoplanets

982
00:44:19,810 --> 00:44:17,480
looking very deeply at these gold areas

983
00:44:22,390 --> 00:44:19,820
of the sky Tess is going to know the

984
00:44:25,930 --> 00:44:22,400
lawn and discover all kinds of planets

985
00:44:30,310 --> 00:44:25,940
around the wide part of the sky but

986
00:44:33,580 --> 00:44:30,320
around brighter stars so here are the

987
00:44:36,610 --> 00:44:33,590
first three systems that have been not

988
00:44:39,600 --> 00:44:36,620

only discovered but verified and I'll go

989
00:44:43,540 --> 00:44:39,610
through each one in turn you can see the

990
00:44:46,510 --> 00:44:43,550
locations of the house stars on the FF

991
00:44:51,540 --> 00:44:46,520
fives which are these full-frame images

992
00:44:55,240 --> 00:44:51,550
for short here's PI menses location LH s

993
00:44:57,310 --> 00:44:55,250
3844 and HD - one seven two four nine

994
00:44:59,500 --> 00:44:57,320
you'd never be able to tell these apart

995
00:45:01,570 --> 00:44:59,510
from any other one unless you sit down

996
00:45:03,520 --> 00:45:01,580
and look at all the measurements and

997
00:45:05,110 --> 00:45:03,530
figure out which ones of these things

998
00:45:06,610 --> 00:45:05,120
are twinkling in ways that we care about

999
00:45:07,690 --> 00:45:06,620
for exoplanets which ones are doing

1000
00:45:10,930 --> 00:45:07,700
other things which ones are doing

1001
00:45:14,980 --> 00:45:10,940
nothing that's the beauty of Tess so

1002
00:45:17,620 --> 00:45:14,990
let's start with hi men see so this is a

1003
00:45:20,020 --> 00:45:17,630
very interesting house star it's

1004
00:45:20,800 --> 00:45:20,030
actually pretty close by it's about 60

1005
00:45:22,690 --> 00:45:20,810
light years away

1006
00:45:25,210 --> 00:45:22,700
this is going to be a common theme by

1007
00:45:26,980 --> 00:45:25,220
the way for all three planets it's so

1008
00:45:28,930 --> 00:45:26,990
bright that if you're in the southern

1009
00:45:30,880 --> 00:45:28,940
hemisphere say you go to Chile or

1010
00:45:33,430 --> 00:45:30,890
Australia or something you can actually

1011
00:45:34,990 --> 00:45:33,440
see the star with your naked eye in the

1012
00:45:37,690 --> 00:45:35,000
southern mystery that's how bright and

1013
00:45:39,610 --> 00:45:37,700

close the star is this

1014
00:45:41,950 --> 00:45:39,620
itself is pretty similar to the Sun it's

1015
00:45:44,950 --> 00:45:41,960
about 10% larger in mass and size

1016
00:45:46,990 --> 00:45:44,960
compared to the Sun and the planet is

1017
00:45:49,420 --> 00:45:47,000
one of these really interesting examples

1018
00:45:53,680 --> 00:45:49,430
of something we don't have in the solar

1019
00:45:55,420 --> 00:45:53,690
system the planets radius the size is

1020
00:45:57,910 --> 00:45:55,430
about double that of the earth and the

1021
00:45:59,470 --> 00:45:57,920
matte mass is about 5 times the mass of

1022
00:46:01,390 --> 00:45:59,480
the earth there's no such example of

1023
00:46:03,640 --> 00:46:01,400
this in our solar system you sort of

1024
00:46:06,700 --> 00:46:03,650
jump from earth all the way up to the

1025
00:46:08,410 --> 00:46:06,710
ice giants Uranus and Neptune the

1026
00:46:10,960 --> 00:46:08,420
orbital period is one of these

1027
00:46:13,900 --> 00:46:10,970
characteristic short period planets it

1028
00:46:16,030 --> 00:46:13,910
takes about six days for it to do one

1029
00:46:18,820 --> 00:46:16,040
complete orbit around the star so it's

1030
00:46:22,480 --> 00:46:18,830
very close to its host star much closer

1031
00:46:24,730 --> 00:46:22,490
than mercury an important point is if

1032
00:46:26,860 --> 00:46:24,740
you can measure the mass and the radius

1033
00:46:29,440 --> 00:46:26,870
for the planet which we have done in

1034
00:46:31,180 --> 00:46:29,450
this case you can take mass divided by

1035
00:46:33,790 --> 00:46:31,190
the radius cubed and you get something

1036
00:46:35,770 --> 00:46:33,800
called density and this is sort of an

1037
00:46:39,880 --> 00:46:35,780
average density but it allows us to make

1038
00:46:42,310 --> 00:46:39,890

very basic claims about what the planet

1039
00:46:44,590 --> 00:46:42,320
might be made out of we can show for

1040
00:46:46,810 --> 00:46:44,600
example that based on our measurement of

1041
00:46:49,180 --> 00:46:46,820
the planet's mass and radius it cannot

1042
00:46:51,400 --> 00:46:49,190
be made entirely out of iron for example

1043
00:46:53,980 --> 00:46:51,410
it cannot be made entirely out of gas

1044
00:46:56,350 --> 00:46:53,990
for example in fact we are able to

1045
00:46:59,040 --> 00:46:56,360
identify that the planet is likely a

1046
00:47:02,080 --> 00:46:59,050
combination of rocky material and

1047
00:47:03,160 --> 00:47:02,090
probably some kind of gas we don't know

1048
00:47:06,160 --> 00:47:03,170
whether it's a hydrogen helium

1049
00:47:08,740 --> 00:47:06,170
atmosphere or perhaps a water or methane

1050
00:47:10,960 --> 00:47:08,750
atmosphere it might be thin might be

1051
00:47:12,970 --> 00:47:10,970
relatively thick this is where follow-up

1052
00:47:16,210 --> 00:47:12,980
observations are needed including from

1053
00:47:18,250 --> 00:47:16,220
James Webb the other mentioned the other

1054
00:47:19,720 --> 00:47:18,260
quick thing I'll mention is that there

1055
00:47:22,510 --> 00:47:19,730
was actually another planet that was

1056
00:47:25,360 --> 00:47:22,520
previously known around the star already

1057
00:47:29,500 --> 00:47:25,370
much farther away takes five years for

1058
00:47:31,570 --> 00:47:29,510
that planet to go around pieman star and

1059
00:47:34,120 --> 00:47:31,580
it's huge it's ten times the mass of

1060
00:47:36,700 --> 00:47:34,130
Jupiter it's almost a star in its own

1061
00:47:39,910 --> 00:47:36,710
right so the first exoplanet discovery

1062
00:47:41,500 --> 00:47:39,920
by Tess was actually a second planet in

1063
00:47:43,720 --> 00:47:41,510

a known system which is really

1064
00:47:46,450 --> 00:47:43,730
interesting and it's going to be a lot

1065
00:47:49,090 --> 00:47:46,460
more of these as time moves on and the

1066
00:47:51,280 --> 00:47:49,100
plot on the right is taken straight from

1067
00:47:54,580 --> 00:47:51,290
the paper that announced

1068
00:47:56,320 --> 00:47:54,590
the discovery of this on the axis up and

1069
00:47:58,780 --> 00:47:56,330
down is basically a measurement of the

1070
00:48:01,000 --> 00:47:58,790
brightness of the star as a function of

1071
00:48:02,500 --> 00:48:01,010
time and you can see if you remember

1072
00:48:04,390 --> 00:48:02,510
back when I showed the little animation

1073
00:48:05,650 --> 00:48:04,400
of what happens when a star goes in

1074
00:48:08,260 --> 00:48:05,660
front when a planet goes in front of the

1075
00:48:12,010 --> 00:48:08,270
star we see a very characteristic drop

1076
00:48:13,600 --> 00:48:12,020
in the flux while pieman C is going in

1077
00:48:15,520 --> 00:48:13,610
front and blocking all the light and

1078
00:48:18,010 --> 00:48:15,530
then it goes back to normal again so

1079
00:48:20,170 --> 00:48:18,020
this these kinds of plots which we call

1080
00:48:22,210 --> 00:48:20,180
white curves or what we really want to

1081
00:48:24,850 --> 00:48:22,220
get out of tests to then study and

1082
00:48:28,570 --> 00:48:24,860
measure properties of the plants that we

1083
00:48:30,970 --> 00:48:28,580
find here's the second planet and it

1084
00:48:33,310 --> 00:48:30,980
couldn't be more different so again we

1085
00:48:34,690 --> 00:48:33,320
have the characteristic shape of the

1086
00:48:37,150 --> 00:48:34,700
brightness of the star sort of sitting

1087
00:48:39,550 --> 00:48:37,160
there being find that up way that drops

1088
00:48:42,430 --> 00:48:39,560

down as a planet blocking this

1089
00:48:45,970 --> 00:48:42,440
particular star but the host star is

1090
00:48:49,060 --> 00:48:45,980
very very different from PI men LHS 3844

1091
00:48:53,140 --> 00:48:49,070
we call an M dwarf it's very very small

1092
00:48:56,470 --> 00:48:53,150
it's about 15% the mass of the Sun and

1093
00:49:00,400 --> 00:48:56,480
about 20% of the size it was very tiny

1094
00:49:02,380 --> 00:49:00,410
star it's red it's cool and they are

1095
00:49:04,420 --> 00:49:02,390
some of the most interesting targets for

1096
00:49:06,850 --> 00:49:04,430
exoplanets and habitability in our solar

1097
00:49:08,920 --> 00:49:06,860
system but the one thing it does share

1098
00:49:10,990 --> 00:49:08,930
in common with the previous planet and

1099
00:49:13,180 --> 00:49:11,000
it's close it's about 49 light years

1100
00:49:15,490 --> 00:49:13,190
away and it may seem far but when I

1101
00:49:19,120 --> 00:49:15,500
compare to other known planets it's

1102
00:49:22,060 --> 00:49:19,130
actually pretty close by the plot itself

1103
00:49:24,700 --> 00:49:22,070
is about 30% larger than the earth so

1104
00:49:28,000 --> 00:49:24,710
it's pretty small what's amazing is that

1105
00:49:31,990 --> 00:49:28,010
it takes 11 hours for this to orbit the

1106
00:49:35,320 --> 00:49:32,000
star half a day is one year on this

1107
00:49:38,980 --> 00:49:35,330
planet for context mercury the closest

1108
00:49:41,020 --> 00:49:38,990
planet to our Sun takes 88 days to go

1109
00:49:44,710 --> 00:49:41,030
around the Sun this thing takes 11 hours

1110
00:49:47,410 --> 00:49:44,720
to go around this star remarkably short

1111
00:49:49,840 --> 00:49:47,420
orbital period because it's so close

1112
00:49:53,440 --> 00:49:49,850
it's not a night place nice place to be

1113
00:49:54,880 --> 00:49:53,450

even in January the temperature on this

1114
00:49:58,240 --> 00:49:54,890
planet was something like a thousand

1115
00:50:00,070 --> 00:49:58,250
degrees Fahrenheit estimated not to

1116
00:50:03,080 --> 00:50:00,080
mention that it's being bombarded by all

1117
00:50:05,550 --> 00:50:03,090
kinds of ultraviolet rays and gamma ray

1118
00:50:07,740 --> 00:50:05,560
the atmosphere is probably been baked

1119
00:50:09,540 --> 00:50:07,750
off so there's no protection at all for

1120
00:50:12,840 --> 00:50:09,550
anybody you might be on the surface it's

1121
00:50:16,140 --> 00:50:12,850
a horrible place to be but in the

1122
00:50:18,900 --> 00:50:16,150
context of understanding how plants form

1123
00:50:22,230 --> 00:50:18,910
around stars it's vital because we want

1124
00:50:24,000 --> 00:50:22,240
to understand how is it that you got to

1125
00:50:26,190 --> 00:50:24,010
where you are it tells us a lot about

1126
00:50:30,690 --> 00:50:26,200
how plants form and how they change over

1127
00:50:32,790 --> 00:50:30,700
time the last exoplanet that was

1128
00:50:36,780 --> 00:50:32,800
discovered and was recently announced is

1129
00:50:40,980 --> 00:50:36,790
HD 21 40 79 and it's interesting because

1130
00:50:43,520 --> 00:50:40,990
once again it's sort of in between the

1131
00:50:46,440 --> 00:50:43,530
types of planets from the previous two

1132
00:50:48,780 --> 00:50:46,450
again it's very close it's about 52

1133
00:50:51,120 --> 00:50:48,790
light years away so all three are very

1134
00:50:52,380 --> 00:50:51,130
close to the Sun in terms of other stars

1135
00:50:56,220 --> 00:50:52,390
it's doing what we call the solar

1136
00:50:58,800 --> 00:50:56,230
neighborhood this star itself is sort of

1137
00:51:01,770 --> 00:50:58,810
in-between the previous time men's

1138
00:51:04,230 --> 00:51:01,780

planet a host star and and LHS is host

1139
00:51:07,050 --> 00:51:04,240
star it's about 75% as massive as the

1140
00:51:09,750 --> 00:51:07,060
song about 70% its size so this is what

1141
00:51:11,790 --> 00:51:09,760
we call an orange K dwarf star they're

1142
00:51:14,370 --> 00:51:11,800
very interesting in their own right the

1143
00:51:17,160 --> 00:51:14,380
planet is sort of we call it tiny

1144
00:51:19,410 --> 00:51:17,170
Neptune or a sub Neptune so it's an ice

1145
00:51:22,380 --> 00:51:19,420
giant we think but it's so much smaller

1146
00:51:25,500 --> 00:51:22,390
than Neptune it's about three times the

1147
00:51:27,570 --> 00:51:25,510
size of the earth about 23 25 times the

1148
00:51:29,100 --> 00:51:27,580
mass of the earth so it's probably some

1149
00:51:31,020 --> 00:51:29,110
sort of ice giant perhaps a little bit

1150
00:51:34,560 --> 00:51:31,030
smaller than what we have in our solar

1151
00:51:36,330 --> 00:51:34,570
system and it takes 35 days to over its

1152
00:51:38,790 --> 00:51:36,340
host are still within the orbit of

1153
00:51:42,120 --> 00:51:38,800
mercury right but compared to the other

1154
00:51:43,650 --> 00:51:42,130
two much further away the other

1155
00:51:46,650 --> 00:51:43,660
interesting thing about this system is

1156
00:51:49,530 --> 00:51:46,660
in the discovery paper there is evidence

1157
00:51:53,220 --> 00:51:49,540
of a second planet in this star system

1158
00:51:56,040 --> 00:51:53,230
this is actually very very similar to

1159
00:51:59,660 --> 00:51:56,050
the radius of the earth and if we can

1160
00:52:03,630 --> 00:51:59,670
measure its mass this might be the first

1161
00:52:06,450 --> 00:52:03,640
earth-sized an earth-mass planet

1162
00:52:08,130 --> 00:52:06,460
discovered by tennis not habitable

1163
00:52:10,380 --> 00:52:08,140

because the orbital period is only eight

1164
00:52:12,330 --> 00:52:10,390
days so it's getting baked just as much

1165
00:52:15,300 --> 00:52:12,340
as anything else but it shows we're able

1166
00:52:16,890 --> 00:52:15,310
to find these and perhaps perhaps be

1167
00:52:19,500 --> 00:52:16,900
able to characterize the atmosphere

1168
00:52:22,200 --> 00:52:19,510
years of some of these planets that are

1169
00:52:24,510 --> 00:52:22,210
similar to the earth in its size and its

1170
00:52:26,790 --> 00:52:24,520
mass very exciting so we should stay

1171
00:52:28,650 --> 00:52:26,800
tuned for more more information about

1172
00:52:32,580 --> 00:52:28,660
whether the second planet signal is real

1173
00:52:34,890 --> 00:52:32,590
or a false positive just a highlight

1174
00:52:38,580 --> 00:52:34,900
again the difference is tiny tiny

1175
00:52:41,430 --> 00:52:38,590
planets compared to huge neptune planets

1176
00:52:45,660 --> 00:52:41,440
no atmosphere and boiling ly hot around

1177
00:52:48,480 --> 00:52:45,670
a red mm dwarf sort of a tiny Neptune

1178
00:52:50,490 --> 00:52:48,490
orbiting an orange K dwarf now we have

1179
00:52:53,040 --> 00:52:50,500
PI manages this weird sort of super

1180
00:52:54,930 --> 00:52:53,050
earth class planet that we don't really

1181
00:52:57,990 --> 00:52:54,940
have examples of our own solar system

1182
00:53:00,480 --> 00:52:58,000
but orbiting star that's pretty similar

1183
00:53:03,240 --> 00:53:00,490
to the Sun so these first three by

1184
00:53:05,760 --> 00:53:03,250
themselves really show the diversity of

1185
00:53:07,680 --> 00:53:05,770
types of planets around different types

1186
00:53:10,620 --> 00:53:07,690
of stars that we're gonna find in tests

1187
00:53:13,260 --> 00:53:10,630
and there are hundreds of other

1188
00:53:15,390 --> 00:53:13,270

candidate planets that astronomers are

1189
00:53:16,980 --> 00:53:15,400
following up right now with telescopes

1190
00:53:19,830 --> 00:53:16,990
from around the world and this is just

1191
00:53:21,870 --> 00:53:19,840
from the first couple of months of the

1192
00:53:23,610 --> 00:53:21,880
two-year mission so stay tuned there'll

1193
00:53:29,040 --> 00:53:23,620
be a lot of new discoveries coming in

1194
00:53:30,930 --> 00:53:29,050
2019 and 2020 for sure just a highlight

1195
00:53:33,360 --> 00:53:30,940
this fact even further about how

1196
00:53:36,630 --> 00:53:33,370
important it is to discover nearby

1197
00:53:39,110 --> 00:53:36,640
planets here is the location of the Sun

1198
00:53:41,310 --> 00:53:39,120
and these little circles sort of show

1199
00:53:43,650 --> 00:53:41,320
distances away from us right so this

1200
00:53:46,440 --> 00:53:43,660
circle represents ten light years away

1201
00:53:48,390 --> 00:53:46,450
this circles 30 light years away and as

1202
00:53:50,820 --> 00:53:48,400
we go further and further out we get

1203
00:53:53,880 --> 00:53:50,830
more and more stars in our neighborhood

1204
00:53:55,950 --> 00:53:53,890
and so the location of the first three

1205
00:53:56,880 --> 00:53:55,960
planets you notice you may have noticed

1206
00:53:58,920 --> 00:53:56,890
I'll have roughly the same distance

1207
00:54:00,720 --> 00:53:58,930
they're all roughly the same distance

1208
00:54:04,920 --> 00:54:00,730
away from the Sun they're pretty close

1209
00:54:07,050 --> 00:54:04,930
by if I add some of the previously

1210
00:54:09,810 --> 00:54:07,060
discovered planets you can see that

1211
00:54:12,630 --> 00:54:09,820
these three that come out are already

1212
00:54:14,970 --> 00:54:12,640
sort of in the top ten or twenty closest

1213
00:54:16,440 --> 00:54:14,980

planets we know about to the Sun which

1214
00:54:19,320 --> 00:54:16,450
is already exciting there's going to be

1215
00:54:22,680 --> 00:54:19,330
a lot more coming in fact we can make

1216
00:54:25,800 --> 00:54:22,690
some predictions so this is assert as a

1217
00:54:27,900 --> 00:54:25,810
simulation where we know which stars

1218
00:54:30,260 --> 00:54:27,910
Tess is observing and we know how common

1219
00:54:34,550 --> 00:54:30,270
planets are and so we can predict

1220
00:54:36,530 --> 00:54:34,560
roughly how many stars near the earth

1221
00:54:38,480 --> 00:54:36,540
will be detect plants around you can see

1222
00:54:40,550 --> 00:54:38,490
Tess is really going to fill in there

1223
00:54:42,920 --> 00:54:40,560
really really close by known planets

1224
00:54:45,200 --> 00:54:42,930
that are discovered and as we zoom out

1225
00:54:48,980 --> 00:54:45,210
to further and further distances you can

1226
00:54:51,350 --> 00:54:48,990
see Tess is really gonna fill in all of

1227
00:54:54,560 --> 00:54:51,360
the known exoplanets that are as close

1228
00:54:56,540 --> 00:54:54,570
to the Sun as we can get in blue you

1229
00:54:58,880 --> 00:54:56,550
actually have the Kepler detection and

1230
00:55:02,450 --> 00:54:58,890
you see that while Kepler discovered

1231
00:55:04,940 --> 00:55:02,460
lots and lots of planets unfortunately a

1232
00:55:06,770 --> 00:55:04,950
lot of them are really far away and so

1233
00:55:09,560 --> 00:55:06,780
well we can detect them and measure some

1234
00:55:11,690 --> 00:55:09,570
basic properties but we really can't do

1235
00:55:13,250 --> 00:55:11,700
very well let's get follow-up data to

1236
00:55:15,920 --> 00:55:13,260
really characterize what they're like

1237
00:55:19,130 --> 00:55:15,930
try to measure atmospheric compositions

1238
00:55:22,010 --> 00:55:19,140

try to predict whether there's strong

1239
00:55:25,220 --> 00:55:22,020
winds on some of these gas giants things

1240
00:55:27,109 --> 00:55:25,230
like that so the tests discoveries which

1241
00:55:30,800 --> 00:55:27,119
should fill in this yellow space are

1242
00:55:34,070 --> 00:55:30,810
designed to do exactly that this is one

1243
00:55:36,410 --> 00:55:34,080
last way of showing that's this point so

1244
00:55:38,810 --> 00:55:36,420
on the up-and-down direction you have

1245
00:55:42,650 --> 00:55:38,820
the size of discovered planets relative

1246
00:55:45,020 --> 00:55:42,660
to the earth so this is one earth radius

1247
00:55:46,670 --> 00:55:45,030
this is a planet that would be twice the

1248
00:55:50,300 --> 00:55:46,680
size of Earth three times the size of

1249
00:55:52,760 --> 00:55:50,310
Earth etc and on the left and right

1250
00:55:55,580 --> 00:55:52,770
direction we have distance away from the

1251
00:55:58,400 --> 00:55:55,590
Sun so in black are some of these

1252
00:56:03,349 --> 00:55:58,410
previously discovered planets from the

1253
00:56:06,620 --> 00:56:03,359
ground primarily that have been you know

1254
00:56:09,260 --> 00:56:06,630
orbiting really really close stars to

1255
00:56:11,750 --> 00:56:09,270
the Sun and in blue we have the kepler

1256
00:56:13,820 --> 00:56:11,760
and k2 discoveries and one thing I hope

1257
00:56:17,060 --> 00:56:13,830
you'll all notice is that they're all on

1258
00:56:20,690 --> 00:56:17,070
the right and this plot a lot of them

1259
00:56:23,660 --> 00:56:20,700
are far away they're 300 500 maybe even

1260
00:56:26,210 --> 00:56:23,670
a few thousand light years away which

1261
00:56:28,460 --> 00:56:26,220
make it very hard to study them in a lot

1262
00:56:31,220 --> 00:56:28,470
of detail here's where those test

1263
00:56:34,609 --> 00:56:31,230

predictions come in Tess is gonna find

1264
00:56:36,470 --> 00:56:34,619
lots and lots of small planets one times

1265
00:56:40,070 --> 00:56:36,480
two times three times the size of the

1266
00:56:42,590 --> 00:56:40,080
earth orbiting only 30 or 50 or maybe a

1267
00:56:44,030 --> 00:56:42,600
few hundred light years away and these

1268
00:56:46,010 --> 00:56:44,040
are the ones we can

1269
00:56:48,560 --> 00:56:46,020
really follow up with telescopes like

1270
00:56:49,640 --> 00:56:48,570
Hubble and James Webb and from some of

1271
00:56:54,170 --> 00:56:49,650
the most powerful ground-based

1272
00:56:56,450 --> 00:56:54,180
telescopes around the world so I wanted

1273
00:56:58,130 --> 00:56:56,460
to leave you with a quick summary the

1274
00:57:00,050 --> 00:56:58,140
first public data release has happened

1275
00:57:01,490 --> 00:57:00,060
here in Baltimore if you're from

1276
00:57:04,070 --> 00:57:01,500
Baltimore you can be proud to know where

1277
00:57:05,960 --> 00:57:04,080
the helmet tests long-term the first

1278
00:57:07,160 --> 00:57:05,970
test exoplanets have been discovered and

1279
00:57:09,080 --> 00:57:07,170
published and I shared with you the

1280
00:57:11,540 --> 00:57:09,090
first three that have been published

1281
00:57:13,640 --> 00:57:11,550
there are hundreds of exoplanet

1282
00:57:16,190 --> 00:57:13,650
candidates actively being followed up by

1283
00:57:18,260 --> 00:57:16,200
astronomers around the world as we speak

1284
00:57:20,630 --> 00:57:18,270
so there'll be a lot more discoveries

1285
00:57:23,720 --> 00:57:20,640
coming in the next few months and even

1286
00:57:26,090 --> 00:57:23,730
the next two years the spacecraft isn't

1287
00:57:28,090 --> 00:57:26,100
is very healthy it's actually starting

1288
00:57:30,410 --> 00:57:28,100

at seventh sector just a week ago

1289
00:57:32,570 --> 00:57:30,420
observations are ongoing data are being

1290
00:57:36,530 --> 00:57:32,580
downloaded from the spacecraft to earth

1291
00:57:37,730 --> 00:57:36,540
every two weeks and the initial

1292
00:57:39,290 --> 00:57:37,740
discoveries in other areas of

1293
00:57:41,900 --> 00:57:39,300
astrophysics are happening now as well

1294
00:57:43,760 --> 00:57:41,910
you have asteroids and comets all kinds

1295
00:57:47,150 --> 00:57:43,770
of stellar astrophysics supernovae all

1296
00:57:49,070 --> 00:57:47,160
kinds of bonus science so what's really

1297
00:57:52,550 --> 00:57:49,080
interesting is that every single one of

1298
00:57:56,900 --> 00:57:52,560
these planets that we find with tests

1299
00:57:59,960 --> 00:57:56,910
are going to be new worlds around nearby

1300
00:58:02,210 --> 00:57:59,970
stars it has an exoplanet scientist we

1301
00:58:04,640 --> 00:58:02,220
are super excited to be able to work

1302
00:58:05,570 --> 00:58:04,650
hard every day to confirm as many of

1303
00:58:09,530 --> 00:58:05,580
these as possible

1304
00:58:12,710 --> 00:58:09,540
because after all we think it's you know

1305
00:58:16,640 --> 00:58:12,720
by far time for us to meet our neighbors

1306
00:58:18,200 --> 00:58:16,650
and that's what we're doing so thanks

1307
00:58:20,060 --> 00:58:18,210
for your attention and I'll take any

1308
00:58:23,720 --> 00:58:20,070
questions you have

1309
00:58:34,370 --> 00:58:23,730
[Applause]

1310
00:58:36,800 --> 00:58:34,380
oh yeah so I have a limited supply this

1311
00:58:38,480 --> 00:58:36,810
is all I could steal from the meeting of

1312
00:58:40,160 --> 00:58:38,490
test mission stickers but if you'd like

1313
00:58:42,650 --> 00:58:40,170

one after the question session feel free

1314
00:58:45,560 --> 00:58:42,660
to come up and grab one and if we run

1315
00:59:00,830 --> 00:58:45,570
out I may even try to pilfer some more

1316
00:59:02,840 --> 00:59:00,840
and give it to Frank let's start over

1317
00:59:03,859 --> 00:59:02,850
here how about you wait wait wait wait

1318
00:59:13,700 --> 00:59:03,869
for the microphone it's gonna come

1319
00:59:16,099 --> 00:59:13,710
around very simple question um what is

1320
00:59:19,310 --> 00:59:16,109
the diameter of that orbit of tests did

1321
00:59:21,920 --> 00:59:19,320
you say that's a good question and that

1322
00:59:25,460 --> 00:59:21,930
really tests my limit of the of the

1323
00:59:28,970 --> 00:59:25,470
orbit of the spacecraft I want to say it

1324
00:59:31,730 --> 00:59:28,980
doesn't go much further than the lunar

1325
00:59:34,700 --> 00:59:31,740
orbit but I'm afraid I can't answer with

1326
00:59:37,010 --> 00:59:34,710
any definitive question about it yeah

1327
00:59:39,530 --> 00:59:37,020
all right so but that prompts my comment

1328
00:59:41,960 --> 00:59:39,540
um there was a talk given just just

1329
00:59:45,440 --> 00:59:41,970
recently here about that orbit and I was

1330
00:59:48,170 --> 00:59:45,450
just flabbergasted how stable that word

1331
00:59:50,480 --> 00:59:48,180
I would mention that yeah just tell

1332
00:59:54,290 --> 00:59:50,490
these people are so it was like 20-30

1333
00:59:57,140 --> 00:59:54,300
years no no no ha ha ha so this is

1334
00:59:58,849 --> 00:59:57,150
actually sort of along my line to sort

1335
01:00:01,370 --> 00:59:58,859
of if you're if you're excited by test

1336
01:00:04,010 --> 01:00:01,380
set to advocate so the primary mission

1337
01:00:07,760 --> 01:00:04,020
will end in 2020 there is opportunity

1338
01:00:10,070 --> 01:00:07,770

for us to ask NASA to fund tests to do

1339
01:00:12,320 --> 01:00:10,080
another two years in another two years

1340
01:00:14,750 --> 01:00:12,330
in another two years as long as NASA is

1341
01:00:16,700 --> 01:00:14,760
willing to support the funds the orbit

1342
01:00:17,960 --> 01:00:16,710
of tests is actually balanced for

1343
01:00:20,810 --> 01:00:17,970
something called implied off MIT because

1344
01:00:23,180 --> 01:00:20,820
I lied off mechanism because SpaceX did

1345
01:00:25,370 --> 01:00:23,190
a bang on job of getting it to where it

1346
01:00:27,890 --> 01:00:25,380
wants to go without using much fuel and

1347
01:00:32,380 --> 01:00:27,900
the orbit is so stable the spacecraft

1348
01:00:35,000 --> 01:00:32,390
has enough fuel to last for 300 years

1349
01:00:39,329 --> 01:00:35,010
minimum

1350
01:00:42,390 --> 01:00:39,339
so suffice it to say it will not be fuel

1351
01:00:44,220 --> 01:00:42,400
that causes Tess to stop taking day you

1352
01:00:46,470 --> 01:00:44,230
will either have a hardware failure or

1353
01:00:49,410 --> 01:00:46,480
at some point NASA will make a decision

1354
01:00:51,690 --> 01:00:49,420
to retire the spacecraft and move on to

1355
01:00:53,250 --> 01:00:51,700
another project but there is every

1356
01:00:55,710 --> 01:00:53,260
indication that tests will be able to

1357
01:00:58,859 --> 01:00:55,720
extend not only up to James Webb Space

1358
01:01:00,720 --> 01:00:58,869
Telescope lunch but even past James Webb

1359
01:01:02,940 --> 01:01:00,730
Space Telescope launched finding planets

1360
01:01:05,849 --> 01:01:02,950
studying stellar astrophysics finding

1361
01:01:10,799 --> 01:01:05,859
comets and asteroids so that's an orbit

1362
01:01:14,339 --> 01:01:10,809
okay yeah hi so I have a two-part

1363
01:01:17,039 --> 01:01:14,349

question about the simulated preneur the

1364
01:01:20,819 --> 01:01:17,049
predicted locations of planets the first

1365
01:01:23,130 --> 01:01:20,829
part is how did those predictions map to

1366
01:01:26,400 --> 01:01:23,140
the graphic that you showed us as that

1367
01:01:28,829 --> 01:01:26,410
was 2-dimensional and I didn't quite get

1368
01:01:31,620 --> 01:01:28,839
like how that I guess it was before this

1369
01:01:35,130 --> 01:01:31,630
in the presentation yeah yes I believe

1370
01:01:39,390 --> 01:01:35,140
it was this oh and sorry the second part

1371
01:01:43,769 --> 01:01:39,400
is then how what is the second part is

1372
01:01:47,549 --> 01:01:43,779
the angle a significant part of the the

1373
01:01:50,069 --> 01:01:47,559
simulation or is that is it yeah I guess

1374
01:01:52,259 --> 01:01:50,079
like how did you choose what's how are

1375
01:01:53,999 --> 01:01:52,269
what spots chosen in the simulation yeah

1376
01:01:56,460 --> 01:01:54,009
that's a that's a those are two good

1377
01:01:59,190 --> 01:01:56,470
questions so the orange points here do

1378
01:02:01,769 --> 01:01:59,200
correspond to the orange points on this

1379
01:02:03,749 --> 01:02:01,779
two-dimensional plot and the simulations

1380
01:02:06,120 --> 01:02:03,759
are statistical right so they're not

1381
01:02:08,789 --> 01:02:06,130
necessarily guaranteeing that so-and-so

1382
01:02:11,339 --> 01:02:08,799
planet will have a star it's sort of a

1383
01:02:13,680 --> 01:02:11,349
random simulation where we aren't we

1384
01:02:16,710 --> 01:02:13,690
know which stars and what types of stars

1385
01:02:18,809 --> 01:02:16,720
are in our field of view and we have

1386
01:02:20,819 --> 01:02:18,819
some good numbers from Kepler and from

1387
01:02:22,620 --> 01:02:20,829
the ground of how often certain types of

1388
01:02:25,319 --> 01:02:22,630

planets are found around them so this is

1389
01:02:27,450 --> 01:02:25,329
one instance if you will of Tess's

1390
01:02:29,339 --> 01:02:27,460
predicted yield we could do a similar

1391
01:02:31,529 --> 01:02:29,349
calculation with a slightly different

1392
01:02:33,029 --> 01:02:31,539
random number and have the orange

1393
01:02:35,460 --> 01:02:33,039
circles themselves be around different

1394
01:02:39,059 --> 01:02:35,470
stars and different angles but the key

1395
01:02:42,390 --> 01:02:39,069
point is that the number and overall

1396
01:02:43,890 --> 01:02:42,400
distribution will be roughly similar so

1397
01:02:46,400 --> 01:02:43,900
we could run this a hundred times

1398
01:02:48,160 --> 01:02:46,410
but the point is you still have orange

1399
01:02:50,710 --> 01:02:48,170
points

1400
01:02:52,990 --> 01:02:50,720
Merilee all around here you'll have very

1401
01:02:56,309 --> 01:02:53,000
few out here you'll have very few way

1402
01:02:59,230 --> 01:02:56,319
over here and so it's just sort of a

1403
01:03:00,640 --> 01:02:59,240
testament of the yield and so don't

1404
01:03:02,740 --> 01:03:00,650
worry too much about with which

1405
01:03:04,569 --> 01:03:02,750
individual star has a predicted planet

1406
01:03:07,750 --> 01:03:04,579
around it it's the total number and the

1407
01:03:10,000 --> 01:03:07,760
overall distributions yeah yeah and in

1408
01:03:12,490 --> 01:03:10,010
fact although I don't have the data at

1409
01:03:15,490 --> 01:03:12,500
the meeting they over plotted on this

1410
01:03:17,260 --> 01:03:15,500
the initial candidates that are actually

1411
01:03:18,970 --> 01:03:17,270
detected around the actual stars those

1412
01:03:21,039 --> 01:03:18,980
few hundred I talked about and indeed

1413
01:03:23,230 --> 01:03:21,049

they do sort of overlap right in this

1414
01:03:26,049 --> 01:03:23,240
region so we're in great shape for that

1415
01:03:27,819 --> 01:03:26,059
yeah so there's a question online about

1416
01:03:29,890 --> 01:03:27,829
focusing on like the Gliese e catalog

1417
01:03:31,599 --> 01:03:29,900
goes out to 25 light-years and so it

1418
01:03:34,660 --> 01:03:31,609
sounds like we're gonna get maybe five

1419
01:03:39,270 --> 01:03:34,670
six half a dozen of them inside 30

1420
01:03:44,500 --> 01:03:42,309
yeah so the target selection was a

1421
01:03:48,190 --> 01:03:44,510
multi-year effort of which I played a

1422
01:03:50,079 --> 01:03:48,200
very small part in but indeed we had to

1423
01:03:52,030 --> 01:03:50,089
do a lot of work before the spacecraft

1424
01:03:54,640 --> 01:03:52,040
even launched to figure out which

1425
01:03:57,520 --> 01:03:54,650
targets we want to get the best most

1426
01:03:59,620 --> 01:03:57,530
sort of the fastest measurements on to

1427
01:04:02,920 --> 01:03:59,630
look for planets and so we indeed are

1428
01:04:05,020 --> 01:04:02,930
observing pretty much every M dwarf we

1429
01:04:06,430 --> 01:04:05,030
know about that's bright enough to get

1430
01:04:07,870 --> 01:04:06,440
the signal that we need to find plants

1431
01:04:09,609 --> 01:04:07,880
around because M dwarfs are so

1432
01:04:12,039 --> 01:04:09,619
interesting and then on top of that

1433
01:04:14,829 --> 01:04:12,049
we're also observing as many of the best

1434
01:04:16,420 --> 01:04:14,839
sort of solar like and those K dwarfs I

1435
01:04:18,700 --> 01:04:16,430
mentioned the orange dwarfs that are

1436
01:04:20,079 --> 01:04:18,710
close by and are well it's relatively

1437
01:04:24,089 --> 01:04:20,089
well behaved otherwise we're not

1438
01:04:32,740 --> 01:04:30,400

other questions is there a greater

1439
01:04:35,980 --> 01:04:32,750
likelihood that test will find shorter

1440
01:04:38,500 --> 01:04:35,990
period orbit planets rather than longer

1441
01:04:40,089 --> 01:04:38,510
period orbits yep of course it depends

1442
01:04:43,539 --> 01:04:40,099
on what you mean by short and long but

1443
01:04:45,789 --> 01:04:43,549
the the minimum baseline for a given

1444
01:04:48,609 --> 01:04:45,799
star in tests for the first two years at

1445
01:04:51,520 --> 01:04:48,619
least is about a month because it takes

1446
01:04:53,589 --> 01:04:51,530
one of those orange wedges now if you're

1447
01:04:56,289 --> 01:04:53,599
lucky and you happen to be a star that

1448
01:04:58,960 --> 01:04:56,299
lives in the holes you'll actually get

1449
01:05:01,390 --> 01:04:58,970
twelve months of coverage and so you can

1450
01:05:02,020 --> 01:05:01,400
find orbital periods out to several

1451
01:05:04,900 --> 01:05:02,030
months

1452
01:05:07,150 --> 01:05:04,910
but you are right tests is not really

1453
01:05:08,680 --> 01:05:07,160
designed to measure the question

1454
01:05:11,890 --> 01:05:08,690
Kepler's out to do which is to ask how

1455
01:05:14,380 --> 01:05:11,900
many one year earth-sized planets are

1456
01:05:16,240 --> 01:05:14,390
there Tess's job is to find lots and

1457
01:05:18,730 --> 01:05:16,250
lots of earth sized planets and it will

1458
01:05:20,830 --> 01:05:18,740
be very close so we can actually probe

1459
01:05:22,870 --> 01:05:20,840
the atmospheres of them with James Webb

1460
01:05:26,470 --> 01:05:22,880
and it turns out the best candidates for

1461
01:05:30,100 --> 01:05:26,480
that are planets orbitting bright nearby

1462
01:05:34,000 --> 01:05:30,110
stars as close to the star as they can

1463
01:05:36,040 --> 01:05:34,010

get so you can get lots of samples the

1464
01:05:39,670 --> 01:05:36,050
questions we had a question from online

1465
01:05:41,170 --> 01:05:39,680
the continuous viewing zones sometimes

1466
01:05:47,830 --> 01:05:41,180
those are pointed at the north and south

1467
01:05:50,940 --> 01:05:47,840
galactic polls how are they okay so that

1468
01:05:53,410 --> 01:05:50,950
was the question online was where the

1469
01:05:55,570 --> 01:05:53,420
yeah sorry I didn't I didn't know if I

1470
01:05:58,480 --> 01:05:55,580
wanted to go into ecliptic verses and

1471
01:06:00,460 --> 01:05:58,490
polling but essentially the we got some

1472
01:06:01,300 --> 01:06:00,470
gigs online oh sure no that's awesome

1473
01:06:03,790 --> 01:06:01,310
that that's great

1474
01:06:06,490 --> 01:06:03,800
so yeah I wanna I want to try to get to

1475
01:06:10,060 --> 01:06:06,500
the movie that shows it but if not they

1476
01:06:12,250 --> 01:06:10,070
can go back the the test in the first

1477
01:06:14,410 --> 01:06:12,260
two years is avoiding what we call the

1478
01:06:17,260 --> 01:06:14,420
ecliptic plane which is where the

1479
01:06:19,510 --> 01:06:17,270
majority of our planets around the Sun

1480
01:06:21,490 --> 01:06:19,520
and I'll be asteroids and comets though

1481
01:06:23,530 --> 01:06:21,500
not all of them are sort of located

1482
01:06:25,690 --> 01:06:23,540
which actually avoiding that for the

1483
01:06:28,390 --> 01:06:25,700
first two years but there's a potential

1484
01:06:29,590 --> 01:06:28,400
to go and get those in the next two

1485
01:06:31,720 --> 01:06:29,600
years and that's something we're

1486
01:06:33,250 --> 01:06:31,730
thinking about very hard if NASA funds

1487
01:06:35,320 --> 01:06:33,260
us for two more years of observation yes

1488
01:06:39,280 --> 01:06:35,330

it is the ecliptic poles where the

1489
01:06:57,310 --> 01:06:42,040
[Laughter]

1490
01:07:02,850 --> 01:06:59,920
I'm just interested in how this data can

1491
01:07:10,560 --> 01:07:02,860
feed into changing the Drake Equation

1492
01:07:16,120 --> 01:07:13,660
we always say test is not a statistical

1493
01:07:18,490 --> 01:07:16,130
mission Kepler's

1494
01:07:20,500 --> 01:07:18,500
science objective was to try and do a

1495
01:07:24,730 --> 01:07:20,510
complete survey to sort of answer

1496
01:07:28,210 --> 01:07:24,740
questions like how many stars of type X

1497
01:07:30,190 --> 01:07:28,220
have planets of type Y that was its

1498
01:07:32,050 --> 01:07:30,200
primary objective the targets and the

1499
01:07:33,790 --> 01:07:32,060
whole mission design were designed to

1500
01:07:36,610 --> 01:07:33,800
answer that question

1501
01:07:38,740 --> 01:07:36,620
Tesla's question is different Tess is

1502
01:07:40,840 --> 01:07:38,750
not worried about completeness and

1503
01:07:43,360 --> 01:07:40,850
although people will do statistics on

1504
01:07:45,700 --> 01:07:43,370
these things it's not really even

1505
01:07:47,320 --> 01:07:45,710
sensitive to a lot of the habitable

1506
01:07:48,880 --> 01:07:47,330
zones with the possible exception of

1507
01:07:51,640 --> 01:07:48,890
those M dwarfs because the how those are

1508
01:07:54,390 --> 01:07:51,650
so much closer instead Tess is really

1509
01:07:56,980 --> 01:07:54,400
finding as many of our nearby

1510
01:07:59,920 --> 01:07:56,990
short-period planets of all kinds of

1511
01:08:02,350 --> 01:07:59,930
sizes for two reasons one to understand

1512
01:08:03,610 --> 01:08:02,360
which of our solar neighborhood friends

1513
01:08:05,440 --> 01:08:03,620

our solar neighborhood stars have

1514
01:08:07,390 --> 01:08:05,450
planets around them and they may have

1515
01:08:10,150 --> 01:08:07,400
plants further away if we do follow-up

1516
01:08:12,250 --> 01:08:10,160
and two to enable things like James Webb

1517
01:08:14,110 --> 01:08:12,260
and Hubble and the most powerful

1518
01:08:15,550 --> 01:08:14,120
ground-based telescopes to basically

1519
01:08:18,190 --> 01:08:15,560
detect the compositions of their

1520
01:08:19,599 --> 01:08:18,200
atmospheres which is arguably one step

1521
01:08:21,190 --> 01:08:19,609
of the Drake Equation if you want to

1522
01:08:22,570 --> 01:08:21,200
call it it but it's not really sort of

1523
01:08:24,610 --> 01:08:22,580
measuring a to earth if you've heard it

1524
01:08:26,290 --> 01:08:24,620
before that was really kept visual yeah

1525
01:08:30,220 --> 01:08:26,300
if that would have addresses your

1526
01:08:34,060 --> 01:08:30,230
question I'm happy to talk more as well

1527
01:08:39,700 --> 01:08:34,070
if there's time we're all actors ah yes

1528
01:08:41,320 --> 01:08:39,710
so yeah so this will actually sort of we

1529
01:08:42,910 --> 01:08:41,330
expect to find comparable number

1530
01:08:44,260 --> 01:08:42,920
compared to Kepler the difference of

1531
01:08:47,230 --> 01:08:44,270
course is these stars are much closer to

1532
01:08:50,430 --> 01:08:47,240
us so it will give us a good census

1533
01:08:54,550 --> 01:08:50,440
about planet frequency around

1534
01:09:01,870 --> 01:08:54,560
neighborhood stars we have a question

1535
01:09:05,080 --> 01:09:01,880
here so I was once told that if you were

1536
01:09:07,690 --> 01:09:05,090
looking at stars - what would happen if

1537
01:09:11,320 --> 01:09:07,700
you had an ocean I was told basically

1538
01:09:13,570 --> 01:09:11,330

oceans were where photons went to die is

1539
01:09:16,030 --> 01:09:13,580
that still true would there if you

1540
01:09:18,580 --> 01:09:16,040
happen to find the star that our planet

1541
01:09:20,470 --> 01:09:18,590
that had an ocean on it you're still not

1542
01:09:23,530 --> 01:09:20,480
gonna be able to see it or or the

1543
01:09:26,230 --> 01:09:23,540
atmospheric composition questions more

1544
01:09:26,650 --> 01:09:26,240
well like actual ocean water ocean oh

1545
01:09:29,019 --> 01:09:26,660
yeah

1546
01:09:32,589 --> 01:09:29,029
so for detecting the planet

1547
01:09:34,029 --> 01:09:32,599
it's pretty insensitive because the way

1548
01:09:35,349 --> 01:09:34,039
we're detecting into planets is we're

1549
01:09:38,199 --> 01:09:35,359
just asking is there something in the

1550
01:09:41,289 --> 01:09:38,209
way and whether there's a pure water

1551
01:09:43,029 --> 01:09:41,299
world or rock or iron or gas doesn't

1552
01:09:44,829 --> 01:09:43,039
matter it turns out is gonna block the

1553
01:09:46,390 --> 01:09:44,839
light and we're gonna see a decrease in

1554
01:09:48,609 --> 01:09:46,400
the brightness of the star either way

1555
01:09:51,189 --> 01:09:48,619
the challenge comes with the atmospheric

1556
01:09:53,499 --> 01:09:51,199
composition there's a couple of factors

1557
01:09:55,180 --> 01:09:53,509
that sort of dictate how well we can

1558
01:09:57,430 --> 01:09:55,190
really measure the atmospheric

1559
01:09:59,439 --> 01:09:57,440
composition and even size of these

1560
01:10:01,870 --> 01:09:59,449
planets and one of them is how thick is

1561
01:10:03,729 --> 01:10:01,880
the atmosphere as you might imagine the

1562
01:10:05,560 --> 01:10:03,739
thicker the atmosphere the more

1563
01:10:07,029 --> 01:10:05,570

atmosphere the light has to travel

1564
01:10:09,069 --> 01:10:07,039
through to get to us and so we have an

1565
01:10:11,500 --> 01:10:09,079
easier way of measuring some of the

1566
01:10:13,239 --> 01:10:11,510
details about those properties for pure

1567
01:10:14,560 --> 01:10:13,249
water worlds it can be sometimes a

1568
01:10:16,120 --> 01:10:14,570
challenge because a lot of light might

1569
01:10:18,310 --> 01:10:16,130
bounce off of the atmosphere before it

1570
01:10:19,959 --> 01:10:18,320
gets to us so yeah that's one of the

1571
01:10:22,149 --> 01:10:19,969
reasons why we want to find lots of them

1572
01:10:24,580 --> 01:10:22,159
so that when James Webb is operating in

1573
01:10:26,379 --> 01:10:24,590
a couple of years we can have it start

1574
01:10:28,180 --> 01:10:26,389
off with the best candidates instead of

1575
01:10:30,069 --> 01:10:28,190
sort of spending a lot of time on some

1576
01:10:31,600 --> 01:10:30,079
of these water worlds or other things

1577
01:10:35,020 --> 01:10:31,610
that might not have as good a chance of

1578
01:10:38,140 --> 01:10:35,030
us detecting atmosphere hmm okay so we

1579
01:10:40,060 --> 01:10:38,150
have a question from online how sure are

1580
01:10:42,669 --> 01:10:40,070
you that these light curve dips are

1581
01:10:46,060 --> 01:10:42,679
planets could there be other phenomenon

1582
01:10:48,520 --> 01:10:46,070
that mimic this and how do you that's a

1583
01:10:50,319 --> 01:10:48,530
fantastic question it's actually the

1584
01:10:53,399 --> 01:10:50,329
subject and careers of several

1585
01:10:55,839 --> 01:10:53,409
astronomers myself included actually

1586
01:10:57,339 --> 01:10:55,849
I've been a co-author on papers that

1587
01:10:59,759 --> 01:10:57,349
have disproved planets and ones that

1588
01:11:04,029 --> 01:10:59,769

have proved planets it's actually a

1589
01:11:06,640 --> 01:11:04,039
multi telescope and multi technique

1590
01:11:08,469 --> 01:11:06,650
method but one of so we can do a lot

1591
01:11:10,299 --> 01:11:08,479
from just the shape of the light curves

1592
01:11:12,370 --> 01:11:10,309
themselves we've learned so much from

1593
01:11:14,229 --> 01:11:12,380
Kepler and k2 and other ground-based

1594
01:11:16,359 --> 01:11:14,239
systems you can actually do a pretty

1595
01:11:18,129 --> 01:11:16,369
good job of weeding out false positives

1596
01:11:21,160 --> 01:11:18,139
and there's a variety of those some of

1597
01:11:23,859 --> 01:11:21,170
them include just artifacts or not even

1598
01:11:25,540 --> 01:11:23,869
real a big one or eclipsing binaries

1599
01:11:27,549 --> 01:11:25,550
actually I'm interested in

1600
01:11:30,640 --> 01:11:27,559
scientifically but all the exoplanet

1601
01:11:31,810 --> 01:11:30,650
people say they're junk I want to do

1602
01:11:33,699 --> 01:11:31,820
cool stellar stuff with equal sign

1603
01:11:35,529 --> 01:11:33,709
buyers but the problem is they can

1604
01:11:37,359 --> 01:11:35,539
sometimes look like planets when they're

1605
01:11:39,520 --> 01:11:37,369
not really so there's a couple of ways

1606
01:11:42,130 --> 01:11:39,530
to avoid that one of the best ways to

1607
01:11:44,530 --> 01:11:42,140
really know if a transiting object

1608
01:11:46,090 --> 01:11:44,540
a planet is to look for what we call the

1609
01:11:47,740 --> 01:11:46,100
Doppler effect with the radial velocity

1610
01:11:49,840 --> 01:11:47,750
method and you may have heard about this

1611
01:11:52,180 --> 01:11:49,850
before but it's a different technique it

1612
01:11:54,280 --> 01:11:52,190
requires telescopes on the ground and

1613
01:11:56,890 --> 01:11:54,290

the way that works is once we see a

1614
01:11:58,420 --> 01:11:56,900
signal with a dip we then have the

1615
01:12:01,840 --> 01:11:58,430
hypothesis that this is caused by a

1616
01:12:03,220 --> 01:12:01,850
planet if it's a planet what happens is

1617
01:12:07,810 --> 01:12:03,230
the planets orbiting around the star

1618
01:12:10,330 --> 01:12:07,820
I'll illustrate right because it's being

1619
01:12:11,830 --> 01:12:10,340
tugged on by gravity right gravitational

1620
01:12:13,720 --> 01:12:11,840
pull the star on the planet is having

1621
01:12:16,360 --> 01:12:13,730
this thing go around but Newton's law

1622
01:12:19,120 --> 01:12:16,370
tells us there's an equal but smaller

1623
01:12:22,000 --> 01:12:19,130
effect of the planet on the Sun so if

1624
01:12:25,180 --> 01:12:22,010
you have a very very precise instrument

1625
01:12:27,310 --> 01:12:25,190
you can actually look for myself as the

1626
01:12:29,590 --> 01:12:27,320
Sun now being pulled toward the planet a

1627
01:12:32,470 --> 01:12:29,600
little bit vary a little bit but

1628
01:12:34,360 --> 01:12:32,480
nonetheless measurable as the planet

1629
01:12:35,830 --> 01:12:34,370
goes around it and so if the planets in

1630
01:12:37,450 --> 01:12:35,840
front of me I get pulled a little bit

1631
01:12:39,190 --> 01:12:37,460
toward it now it orbits over here now

1632
01:12:40,840 --> 01:12:39,200
I'm pulled a little bit over here now

1633
01:12:42,730 --> 01:12:40,850
it's behind me and pulled a little bit

1634
01:12:45,610 --> 01:12:42,740
right and so we end up having this

1635
01:12:49,110 --> 01:12:45,620
wobble of these stars you can actually

1636
01:12:51,460 --> 01:12:49,120
detect that believe it or not with

1637
01:12:54,220 --> 01:12:51,470
instruments on the ground the effect

1638
01:13:00,130 --> 01:12:54,230

sometimes the effect we're looking at is

1639
01:13:01,900 --> 01:13:00,140
slower than me walking that's the size

1640
01:13:03,460 --> 01:13:01,910
of the signal we measure with some of

1641
01:13:05,680 --> 01:13:03,470
these instruments but we're able to do

1642
01:13:07,540 --> 01:13:05,690
that with a lot of experience and with

1643
01:13:09,400 --> 01:13:07,550
very big powerful instrument from the

1644
01:13:11,560 --> 01:13:09,410
ground so that's the best way we have of

1645
01:13:13,000 --> 01:13:11,570
detecting it and indeed a few of the

1646
01:13:17,220 --> 01:13:13,010
ones I mentioned have been confirmed by

1647
01:13:19,690 --> 01:13:17,230
that method okay other questions here

1648
01:13:22,120 --> 01:13:19,700
one in the back just to give you some

1649
01:13:28,900 --> 01:13:22,130
exercise grant thank you for running

1650
01:13:30,430 --> 01:13:28,910
with the mycube so I was kind of

1651
01:13:31,990 --> 01:13:30,440
interested in how you said that it

1652
01:13:34,210 --> 01:13:32,000
sounded like a lot of these or most of

1653
01:13:35,860 --> 01:13:34,220
them can be looked at you said they're

1654
01:13:38,830 --> 01:13:35,870
gonna follow up with telescopes from

1655
01:13:41,470 --> 01:13:38,840
Earth yep so are these things that could

1656
01:13:43,210 --> 01:13:41,480
have been seen any way without tests so

1657
01:13:45,430 --> 01:13:43,220
what's test doing is test just helping

1658
01:13:47,500 --> 01:13:45,440
them find them quicker or that's like

1659
01:13:50,380 --> 01:13:47,510
that's a great question there's a couple

1660
01:13:52,180 --> 01:13:50,390
of parts some of these are not able to

1661
01:13:53,680 --> 01:13:52,190
be found with our current instruments

1662
01:13:55,810 --> 01:13:53,690
because some of the things like the

1663
01:13:58,359 --> 01:13:55,820

wobble I mentioned that they induce

1664
01:14:01,510 --> 01:13:58,369
is just too small we can't even see them

1665
01:14:04,000 --> 01:14:01,520
so the other thing it does is the field

1666
01:14:05,140 --> 01:14:04,010
of view most of the instruments I

1667
01:14:07,750 --> 01:14:05,150
mentioned especially the ones that

1668
01:14:10,750 --> 01:14:07,760
measure wobble have to look at one star

1669
01:14:14,109 --> 01:14:10,760
at a time it has to monitor it for

1670
01:14:15,520 --> 01:14:14,119
usually several days and get dozens of

1671
01:14:17,370 --> 01:14:15,530
measurements before it can really show

1672
01:14:21,819 --> 01:14:17,380
that it's a wobble that's happening

1673
01:14:24,760 --> 01:14:21,829
there's 200,000 stars just in the high

1674
01:14:26,649 --> 01:14:24,770
priority list so two hundred thousand

1675
01:14:28,270 --> 01:14:26,659
one at a time you only have a certain

1676
01:14:29,790 --> 01:14:28,280
number of nights per year because the

1677
01:14:33,819 --> 01:14:29,800
telescope's being used for other things

1678
01:14:36,160 --> 01:14:33,829
it becomes impossible to do the size and

1679
01:14:38,500 --> 01:14:36,170
scope of the search from ground-based

1680
01:14:40,510 --> 01:14:38,510
using those methods so you're right your

1681
01:14:43,600 --> 01:14:40,520
your your hype your idea was exactly

1682
01:14:45,250 --> 01:14:43,610
right Tess is a large part of test is

1683
01:14:47,649 --> 01:14:45,260
being able to detect a lot of these

1684
01:14:50,500 --> 01:14:47,659
small planets using the dip technique

1685
01:14:54,040 --> 01:14:50,510
the transit technique with a huge net

1686
01:14:55,959 --> 01:14:54,050
and then we can take the expensive part

1687
01:14:57,879 --> 01:14:55,969
which is going to these huge cells on

1688
01:14:59,919 --> 01:14:57,889

the ground and gain these expensive

1689
01:15:02,350 --> 01:14:59,929
measurements that that cost a lot in

1690
01:15:04,479 --> 01:15:02,360
terms of number of nights and all this

1691
01:15:06,189 --> 01:15:04,489
other stuff to then confirm them once we

1692
01:15:07,209 --> 01:15:06,199
know there's a signal there we don't

1693
01:15:08,740 --> 01:15:07,219
want to have to look at a hundred

1694
01:15:11,140 --> 01:15:08,750
thousand stars I don't doing anything

1695
01:15:13,479 --> 01:15:11,150
that's not a good use of our talisman no

1696
01:15:16,120 --> 01:15:13,489
great question though thank you okay

1697
01:15:17,790 --> 01:15:16,130
time for one more question you've had a

1698
01:15:20,109 --> 01:15:17,800
question that says there's anybody else

1699
01:15:21,640 --> 01:15:20,119
all right come on down here we had

1700
01:15:28,750 --> 01:15:21,650
though this journalist got another

1701
01:15:31,000 --> 01:15:28,760
question well finished off there I'm

1702
01:15:34,330 --> 01:15:31,010
interested in in the effect of the

1703
01:15:37,030 --> 01:15:34,340
orbital period of the planets that were

1704
01:15:40,120 --> 01:15:37,040
detecting I'm as a thought experiment

1705
01:15:43,419 --> 01:15:40,130
I'm thinking if another solar system

1706
01:15:46,750 --> 01:15:43,429
someplace out there was looking at us if

1707
01:15:50,050 --> 01:15:46,760
our periods one year if you didn't

1708
01:15:54,419 --> 01:15:50,060
happen to be looking at earth when we

1709
01:15:56,830 --> 01:15:54,429
occulted the Sun or transited the Sun

1710
01:15:59,850 --> 01:15:56,840
you'd miss it if you are looking for

1711
01:16:02,859 --> 01:15:59,860
Jupiter it's once every 12 - bucks right

1712
01:16:05,890 --> 01:16:02,869
and so how do you how do you allow for

1713
01:16:08,050 --> 01:16:05,900

that what what adjustments do you make

1714
01:16:10,690 --> 01:16:08,060
for that well that's a great question

1715
01:16:13,420 --> 01:16:10,700
giving a lifetime of the current funding

1716
01:16:15,370 --> 01:16:13,430
how long of a period can you see these

1717
01:16:17,710 --> 01:16:15,380
planets so that's a great question and

1718
01:16:20,410 --> 01:16:17,720
the way we get around it is twofold one

1719
01:16:22,090 --> 01:16:20,420
we go to space in space there's no pesky

1720
01:16:24,520 --> 01:16:22,100
a thing called the day/night cycle on

1721
01:16:26,830 --> 01:16:24,530
the ground when it's daytime you can

1722
01:16:30,370 --> 01:16:26,840
observe because it sums up space you can

1723
01:16:31,930 --> 01:16:30,380
observe all day every day and just stare

1724
01:16:33,550 --> 01:16:31,940
at these things and get lots and lots of

1725
01:16:35,830 --> 01:16:33,560
measurements to cuz you don't know when

1726
01:16:36,130 --> 01:16:35,840
it's gonna happen right so a we look at

1727
01:16:38,290 --> 01:16:36,140
them

1728
01:16:41,860 --> 01:16:38,300
all the time during the time we're

1729
01:16:43,870 --> 01:16:41,870
taking gate data - we do it very quickly

1730
01:16:45,370 --> 01:16:43,880
so we're constantly measuring measured

1731
01:16:46,450 --> 01:16:45,380
measurement so almost like OCD right

1732
01:16:49,570 --> 01:16:46,460
measure measure measure measure measure

1733
01:16:52,810 --> 01:16:49,580
measure measure measure and then the the

1734
01:16:56,500 --> 01:16:52,820
third point was about the solar system

1735
01:16:59,470 --> 01:16:56,510
so again Kepler lasted four years and so

1736
01:17:02,410 --> 01:16:59,480
it was able to learn the prime mission

1737
01:17:05,590 --> 01:17:02,420
right it was able to see a signal at

1738
01:17:07,120 --> 01:17:05,600

least one during a one year orbit most

1739
01:17:07,600 --> 01:17:07,130
of tests will not be sensitive to things

1740
01:17:09,610 --> 01:17:07,610
like that

1741
01:17:12,040 --> 01:17:09,620
so we won't be able to see things that

1742
01:17:13,210 --> 01:17:12,050
have one year periods during the prime

1743
01:17:16,510 --> 01:17:13,220
to your mission

1744
01:17:19,750 --> 01:17:16,520
but if NASA decides to fund tests for

1745
01:17:22,450 --> 01:17:19,760
two for six more years now we have

1746
01:17:26,140 --> 01:17:22,460
enough observations that we will be able

1747
01:17:27,970 --> 01:17:26,150
to see single dips caused by something

1748
01:17:30,010 --> 01:17:27,980
that might be very very long period and

1749
01:17:33,730 --> 01:17:30,020
because we have so many stars or such a

1750
01:17:35,260 --> 01:17:33,740
huge part of the sky even if we miss 99%

1751
01:17:35,710 --> 01:17:35,270
of the Jupiter's what or something like

1752
01:17:38,110 --> 01:17:35,720
that

1753
01:17:39,760 --> 01:17:38,120
we need to find one and then follow it

1754
01:17:41,680 --> 01:17:39,770
up and have some patience

1755
01:17:44,620 --> 01:17:41,690
we'll be able to find things potentially

1756
01:17:46,480 --> 01:17:44,630
like Jupiter's at 5 au that take 25

1757
01:17:48,520 --> 01:17:46,490
years to orbit you look at a whole bunch

1758
01:17:51,370 --> 01:17:48,530
of stars you have the one at the right

1759
01:17:53,530 --> 01:17:51,380
time you might be able to get it yeah

1760
01:17:55,750 --> 01:17:53,540
and that's a great perspective on that's

1761
01:17:57,730 --> 01:17:55,760
because you realize that we've only been

1762
01:18:01,660 --> 01:17:57,740
discovering extrasolar planets since

1763
01:18:03,580 --> 01:18:01,670

1990s so we got 20 years Saturn takes

1764
01:18:05,440 --> 01:18:03,590
over 30 years to orbit the Sun we could

1765
01:18:06,990 --> 01:18:05,450
never have found a Saturn in a Saturn

1766
01:18:11,470 --> 01:18:07,000
size orbit with this technique with this

1767
01:18:14,520 --> 01:18:11,480
type of technique so you know exoplanets

1768
01:18:17,260 --> 01:18:14,530
are only gonna get more interesting

1769
01:18:20,290 --> 01:18:17,270
absolutely wonderful presentation on us

1770
01:18:20,669 --> 01:18:20,300
and we can't wait for more stuff you're

1771
01:18:22,110 --> 01:18:20,679
gonna come